MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXXIX. *November* 8, 1878. No. 1.

LORD LINDSAY, M.P., F.R.S., President, in the Chair.

The Rev. J. M. Coates, The Goddards, Moulton, Spalding; and

B. G. Jenkins, Esq., 4 Buccleuch Road, West Dulwich;

were balloted for and duly elected Fellows of the Society.

Dr. C. Brühns, The Observatory, Leipzig;
Baron H. von Dembowski, Gallarate;
G. W. Hill, Esq., New York; and
Prof. E. Schönfeld, The Observatory, Bonn;

were balloted for and duly elected Associates of the Society.

Observations at the Adelaide Observatory. By C. Todd, Esq., Director of the Observatory.

(*Extract from letter to the Astronomer Royal.*)

By to-day's mail I send you the following for the Royal Astronomical Society, viz.:—

Observations of transits, occultations, and eclipses of *Jupiter's* satellites in 1877.

Total eclipse of the Moon on the morning of February 28, 1877.

Partial eclipse of the Sun on February 2, 1878.

Transit of *Mercury* on May 6, 1878.

A few sets of east and west parallax observations of *Mars* at opposition were taken, which I must send you in a future letter. Some sets comprise a large number of differential measurements of R.A., but my chronograph was not very good, and the instrument required a better clamp in R.A. The observations may, however, possess some value, and I will therefore send them for what they are worth. With a better R.A. clamp, which I will make, and a new chronograph I have made since, I think I shall be able to secure better results in future.

With regard to *Jupiter*, the visibility of the satellites through the edge of the planet has been very carefully looked for; and on two occasions I felt quite certain I saw the satellite at occultation within the disk, viz. on June 19, at occultation disappearance of Satellite II, and on July 2, at disappearance of Satellite I. Mr. Ringwood also saw the same phenomenon at the disappearance of Satellite II on August 29. I thought I could see Satellite III through the limb at reappearance on June 9, and Satellite II at disappearance on July 21, but could not be certain. In every other case the occultation was perfect at the limb. On June 19 Satellite II was visible through the white belt south of equator, and on July 2 Satellite I was seen for the space of one minute through the southern dark belt. It would be interesting to know whether this has been seen by other observers. The definition on each occasion was very good, or I should think I might be deceived.

I may mention that the other evening (July 5) I was surprised to see Satellite IV in transit appear as a dark spot instead of the usual bright point when on the less illumined surface near the edge of the planet; in fact it was at entry nearly as black as its shadow, which was just passing off on the other side. This I know has been seen before, both with Satellites III and IV, and must, I presume, be attributed to one side of the satellite reflecting less light than the other, or else to some violent changes in its atmosphere. Before it came on to the disk I noticed that it was fainter than usual.

It may be worth recording, perhaps, that in 1877 the dark belts of *Jupiter* had not, to my eye at least, the same bright metallic lustre that they had in 1876, but appeared to be covered with a thin haze and looked foggy. And this year the southern dark belt is seldom so highly coloured or so well defined as the northern one. I send you a few pencil sketches, which, however, possess very little merit. Please remember, when thinking how little I do, that I am also Postmaster-General and Superintendent of Telegraphs. My meteorological work is well advanced, but comes very slowly from the printer, especially when Parliament is in session. I send you the observations for January 1878, in which you will see I have made several alterations—I trust improvements. The rain stations are differently grouped, and the returns show at a glance the rainfall over different districts within and without the tropics, extending from the north to the south coast (27° of latitude and over 12° of longitude). The 1877 observations are nearly all printed and will be sent to you shortly.

Adelaide, South Australia,
8 *August* 1878.

Transits, Occultations, and Eclipses of Jupiter's Satellites, during the Year 1877.

(Observers—T., Mr. Todd; R., Mr. Ringwood.)

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac.* h m s	Apparent Error of *Nautical Almanac.* m s	Power.
1				First seen	8 53 27·1	23 39 5·8	23 39		200
2	June 1 8 54	T.	I Sh. I.	About bisected	8 54 29·1	23 40 7·8			,,
3				Internal contact	8 55 39·1	23 41 17·8			,,
4				First contact	9 17 52·1	0 3 30·8	0 5		,,
5	9 20	T.	I Tr. I.	Bisected	9 19 58·1	0 5 36·8			,,
6				Internal contact	9 21 36·6	0 7 15·3			,,
7				Internal contact	11 5 9·9	1 50 48·6			,,
8	11 6	T.	I Sh. E.	Bisected	11 6 39·9	1 52 18·6			,,
9				Limb complete	11 8 13·9	1 53 52·6	1 54		,,
10				Internal contact	11 30 46·4	2 16 25·1			,,
11	11 32	T.	I Tr. E.	Bisected	11 32 12·9	2 17 51·6			,,
12				External contact	11 34 19·9	2 19 58·6	2 21		,,
13				First seen	7 34 52·3	22 20 31·0	22 27		,,
14	June 2 7 40	T.	III Oc. R.	About bisected	7 38 52·3	22 24 31·0			,,
15				External contact	7 42 32·3	22 28 11·0			,,

Remarks.

Ref. No.
1 Limb slightly indented.
10 Very exact.
12 Good observation.

Ref. No.
13, 14, 15 — A little late. Planet ill defined and hazy.

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac.* h m s	Apparent Error of *Nautical Almanac.* m s	Power.
16				First seen	8 51 44·2	23 37 22·9	23 39		200
17	June 2 8 53	T.	I Oc. R.	About bisected	8 52 55·2	23 38 33·9			,,
18				External contact	8 54 40·2	23 40 18·9			,,
19				External contact			0 25		,,
20	June 3 9 43	T.	II Sh. I.	Internal contact	9 43 31·8	0 29 10·5			,,
21				External contact	10 26 1·7	1 11 40·4	1 12		,,
22	10 28	T.	II Tr. I.	Bisected	10 28 21·7	1 14 0·4			,,
23				Internal contact	10 30 21·7	1 16 0·4			,,
24	June 9 7 20	T.	III Ec. D.		7 20 34·1	22 6 12·8	22 4 40	−1 32·8	125
25	8 9	T.	I Ec. D.		8 8 45·0	22 54 23·7	22 54 3	−0 20·7	,,
26				First seen	10 35 38·7	1 21 17·4	1 23		200
27	10 37	T.	I Oc. R.	Bisected	10 37 8·7	1 22 47·4			,,
28				External contact	10 38 38·7	1 24 17·4			,,
29				First seen	10 52 33·7	1 38 12·4	1 45		,,
30	10 52	T.	III Oc. R.	Bisected	10 56 8·7	1 41 47·4			,,
31				External contact	11 0 3·7	1 45 42·4			,,
32				Very dim	6 30 32·5	21 16 11·2			125
33	June 12 6 30	R.	II Ec. D.	Just visible	6 30 52·5	21 16 31·2			,,
34				Disappeared	6 31 2·5	21 16 41·2	21 16 9	−0 32·2	,,
35				First seen			0 23		,,
36	9 36	R.	II Oc. R.	Past bisection	9 36 53·8	0 22 32·5			,,
37				External contact	9 37 19·3	0 22 58·0			,,

38	June 16	10 3	T.	I	Ec. D.		10 3 13·1	0 48 51·8	0 48 21	−0 30·8		,,
39		11 20	T.	III	Ec. D.		11 19 43·5	2 5 22·2	2 3 22	−2 0·2		,,
40						External contact	7 12 3·1	21 57 41·8	21 59			200
41	June 17	7 13	T.	I	Tr. I.	Bisected	7 13 33·1	21 59 11·8				,,
42						Internal contact	7 15 23·1	22 1 1·8				,,
43						Internal contact	9 21 56·0	0 7 34·7				,,
44		9 24	T.	I	Sh. E.	About bisected	9 23 3·0	0 8 41·7				,,
45						Last seen	9 24 9·0	0 9 47·7	0 11			,,

Remarks.

Ref. No.

18 Good observation.
19 Lost; came too late.
20 Not good; badly defined; sky hazy.
21, 22, 23 Good; fair definition.
24 Very exact; planet wretchedly defined.
25 Good observation.
26, 27, 28 Not well defined.
29, 30, 31 May be a little late. Good. Planet not very well defined; clouds passing. Had an impression that I saw half the satellite through edge of planet.
33 A mere speck of light.
35 Lost, through clouds.
37 Doubtful.

Ref. No.

38 Very good; disappearing close to planet, which was beautifully defined. Closeness to planet may affect time of disappearance.
39 Very exact; close proximity to planet may, however, affect observation; definition splendid.
40, 41, 42 The satellite entered the planet on the northern margin of the dark belt north of the planet's equator, and its shadow, which preceded it, was not seen till $7^h\ 16^m$, when it appeared in almost tangential contact with satellite, which could be followed for a considerable space across the disk of the planet; the shadow was very sharply defined. Passing clouds partially obscured the planet at times, and the limb was often wavy and tremulous, but the times noted were considered good.
43, 44, 45 Five minutes before internal contact of shadow, the shadow and satellite appeared to be in contact, both, but especially shadow, being sharply defined.

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
46				Internal contact	9 24 29·0	0 10 7·7			200
47	June 17 9 27	T.	I Tr. E.	Bisected	9 25 51·0	0 11 29·7			,,
48				External contact	9 27 43·0	0 13 21·7	0 14		,,
49				First seen	6 45 59·0	21 31 37·7	21 33		125
50	June 18 6 47	T.	I Oc. R.	About bisected	6 47 0·5	21 32 39·2			,,
51				External contact	6 48 19·5	21 33 58·2			,,
52				External contact	9 1 18·1	23 46 56·8			200
53	June 19 9 5	R.	II Oc. D.	About bisected	9 3 29·6	23 49 8·3			,,
54				Internal contact	9 5 14·6	23 50 53·3	23 50		,,
55				Last seen	9 5 29·1	23 51 7·8			,,
56				External contact	8 55 53·8	23 41 32·5	23 42		,,
57	June 24 8 57	T.	I Tr. I.	Bisected	8 57 11·8	23 42 50·5			,,
58				Internal contact	8 58 43·8	23 44 22·5			,,
59				First seen	9 2 34·8	23 48 13·5	23 49		,,
60	9 4	T.	I Sh. I.	About bisected	9 3 54·8	23 49 33·5			,,
61				Internal contact	9 5 39·8	23 51 18·5			,,
62				First seen	8 37 6·3	23 22 45·0	23 23 4	+0 19·0	,,
63	June 25 8 37	R.	I Ec. R.	Quite distinct	8 37 37·8	23 23 16·5			,,
64				Full blaze	8 39 17·8	23 24 56·5			,,

65						Internal contact	6 54 38·0	21 40 16·7			,,
66	June 27	6 58	T.	III	Tr. E.	About bisected	6 57 57·5	21 43 36·2			,,
67						External contact	7 1 59·0	21 47 37·7	21 51		,,
68						Internal contact	7 41 9·0	22 26 47·7			,,
69		7 45	T.	III	Sh. E.	About bisected	7 44 59·0	22 30 37·7			,,
70						Limb complete	7 48 4·0	22 33 42·7	22 36		,,
71	June 28	6 47	T.	II	Sh. I.	External contact			21 30		,,
72						Nearly bisected	6 47 20·1	21 32 58·8			,,
73						Internal contact	9 1 26·1	23 47 4·8			,,
74		9 4	T.	II	Tr. E.	About bisection	9 4 30·4	23 50 9·1			,,
75						External contact	9 6 19·9	23 51 58·6	23 53		,,

Remarks.

Ref. No.

49 Considered rather late; thin fog clouds over sky.

52 Good.

54, 55 Very good; the satellite disappeared behind white cloud belt, but did not finally disappear till within the limb, or about 14½ˢ after time noted of internal contact.

56, 57, 58, 59, 60, 1 Good; satellite and shadow entered on dark belt north of equator; definition of planet superb.

Ref. No.

62, 63, 64 A mere speck. Very good; well defined; Moon close by.

65, 66, 67 Difficult observation, owing to bad definition of satellite; external contact good.

68, 69, 70 Considered good; clouds passing.

72 Cloudy; internal contact not seen.

73 Very exact.

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76				Internal contact	9 28 6·9	0 13 45·6			200
77	June 28 9 30	T.	II Sh. E.	About bisection	9 29 38·9	0 15 17·6			,,
78				Limb complete	9 31 33·4	0 17 12·1	0 18		,,
79				External contact	7 56 59·0	22 42 37·7			,,
80	July 2 8 0	T.	I Oc. D.	About bisected	7 58 39·0	22 44 17·7			,,
81				Internal contact	8 1 15·7	22 46 54·4	22 46		,,
82				Disappearance	8 2 13·5	22 47 52·2			,,
83				Internal contact	7 17 15·2	22 2 53·9			,,
84	July 3 7 20	T.	I Tr. E.	About bisected	7 18 28·2	22 4 6·9			,,
85				External contact	7 20 15·2	22 5 53·9	22 8		,,
86				Internal contact	7 36 18·2	22 21 56·9			,,
87	7 38	T.	I Sh. E.	About bisected	7 37 30·2	22 23 8·9			,,
88				Limb complete	7 39 39·2	22 25 17·9	22 28		,,
89				External contact	8 34 46·2	23 20 24·9	23 22		300
90	July 5 8 37	T.	II Tr. I.	Bisected	8 36 45·2	23 22 23·9			,,
91				Internal contact	8 38 44·2	23 24 22·9			,,
92				First seen	9 20 49·1	0 6 27·8	0 6		,,
93	9 23	T.	II Sh. I.	About bisected	9 22 27·6	0 8 6·3			,,
94				Internal contact	9 24 27·1	0 10 5·8			,,

95												
96		11 20	T.	II	Tr. E.	About bisection	11 19 8·0	2 4 46·7				,,
97						External contact	11 21 31·5	2 7 10·2	2 9			,,
98						Internal contact	12 3 44·0	2 49 22·7				,,
99		12 6	T.	II	Sh. E.	Bisected	12 5 38·0	2 51 16·7				,,
100						Limb complete	12 7 55·5	2 53 34·2	2 54			,,
101	July 7	6 15	T.	II	Ec. R.		6 14 44·2	21 0 22·9	21 1 52	+1 29·1		,,
102						First seen	6 54 53·3	21 40 32·0	21 40 53	+0 21·0		,,
103	July 11	6 57	R.	I	Ec. R.	Quite distinct	6 55 18·3	21 40 57·0				,,
104						Full blaze	6 58 4·3	21 43 43·0				,,
105	July 14	8 51	T.	II	Ec. R.		8 50 38·0	23 36 16·7	23 37 50	+1 33·3		,,

Remarks.

Ref. No.

79, 80, 81, 82 The satellite disappeared behind the dark belt south of the equator, and was distinctly seen through the edge of the planet for the space of its full diameter, not finally disappearing till about one minute after internal contact, the occultation being effected at some distance within the limb. At $7^h\ 59^m\ 18^s$ and at $8^h\ 0^m\ 53^s$ the satellite was noted as partly behind or immersed in the planet and partly protruding as a small nipple on the limb.

85 Satellite passed off north dark belt.

87 Shadow traversed north dark belt.

89, 90, 91 Very good observation; both planet and satellite well defined. The satellite just within the bright band north of the dark belt.

Ref. No.

92, 93, 94 Good observation; shadow very sharply defined. The satellite faintly visible opposite to a bright spot on south side of dark belt.

95, 96, 97 Internal contact a little early. Planet not so well defined as at ingress. Foggy.

98, 99, 100 Planet not very well defined, but observations considered good.

101 Good, caught first glimmer. Observed also by R. with a 4-inch object-glass, time noted being $6^h\ 15^m\ 21^s{\cdot}9$ A.M. T.

102, 103, 104 Planet not well defined, but observations considered good.

105 Very good; caught first glimmer.

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
106				Internal contact	5 54 51·6	20 40 30·3			200
107	July 19 5 57	R.	I Sh. E.	About bisected	5 55 57·6	20 41 36·3			,,
108				Limb complete	5 57 27·6	20 43 6·3	20 46		,,
109				External contact	7 12 29·8	21 58 8·5			,,
110	July 21 7 15	T.	II Oc. D.	About bisected	7 14 48·8	22 0 27·5			,,
111				Internal contact	7 17 18·8	22 2 57·5	22 1		,,
112	11 28	T.	II Ec. R.	First seen	11 26 30·5	2 12 9·2	2 14 3	+1 53·8	,,
113				Full blaze	11 31 3·5	2 16 42·2			,,
114				First seen	6 46 51·8	21 32 30·5	21 40		,,
115	July 22 6 50	T.	III Oc. R.	About bisected	6 49 21·8	21 35 0·5			,,
116				External contact	6 53 11·8	21 38 50·5			,,
117				Becoming dim	7 4 1·8	21 49 40·5			,,
118	7 10	T.	III Ec. D.	Sensibly dimmer	7 5 32·8	21 51 11·5			,,
119				Disappeared	7 13 25·8	21 59 4·5	21 57 43	−1 21·5	,,
120	9 50	T.	III Ec. R.	First seen	9 48 33·6	0 34 12·3	0 38 25	+4 12·7	,,
121				Full blaze	9 58 1·6	0 43 40·3			,,
122				External contact	10 20 55·2	1 6 33·9	1 9		,,
123	July 24 10 20	T.	I Tr. I.	About bisected	10 22 27·7	1 8 6·4			,,
124				Internal contact	10 24 52·2	1 10 30·9			,,

125						First seen	11 9 29·1	1 55 7·8	1 56		"
126		11 10	T.	I	Sh. I.	About bisected	11 10 54·6	1 56 33·3			"
127						Internal contact	11 12 51·6	1 58 30·3			"
128	July 25	7 41	T.	I	Oc. D.	External contact	7 41 4·2	22 26 42·9			300
129						Disappeared	7 44 45·2	22 30 23·9	22 28		"
130						External contact	9 31 20·1	0 16 58·8			200
131	July 28	9 38	T.	II	Oc. D.	About bisected	9 33 58·1	0 19 36·8			"
132						Disappeared	9 37 9·1	0 22 47·8	0 21		"

Remarks.

Ref. No.

106, 107, 108 } Very good; shadow traversed dark band.

109, 110, 111 } Very good; planet well defined. Satellite disappeared a little south of southern dark belt, behind a bank of white cloud, and at times I thought I could see the whole of the satellite immersed in the planet up to internal contact.

112 Good; a mere speck of light.

114 Time late.

116 Good. Planet and satellite well defined.

117, 118, 119 } The disk of the satellite was very sharply defined. The time first noted is when I first observed an alteration in the outline of the disk, the altered form being well marked at the second time, when the shadow appeared to extend over nearly one-third of the disk. The satellite was reduced to a mere speck of light for at least a minute before disappearance, and I lost sight of it for a few seconds about 10 seconds before the time noted (119) but caught it again, and the time given must be very exact.

120 Good; seen instantly.

121 Disk perfect.

122, 123, 124 } Bad definition.

125, 126, 127 } External contact doubtful; definition wretched.

128, 129 } Not good, clouds interfering; satellite disappeared behind a bright white cloud belt.

130 Not very good.

131 Not very good.

132 Exact.

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
133				External contact	7 30 49·8	22 16 28·5			200
134	July 29 7 42	T.	III Oc. D.	About bisected	7 35 44·8	22 21 23·5			,,
135				Disappeared	7 41 24·8	22 27 3·5	22 22		,,
136				First seen	10 16 14·4	1 1 53·1	1 8		,,
137	10 17	T.	III Oc. R.	About bisected	10 20 4·4	1 5 43·1			,,
138				External contact	10 25 14·4	1 10 53·1			,,
139				First seen	6 28 17·5	21 13 56·2	21 13		,,
140	July 30 6 30	T.	II Sh. I.	About bisected	6 29 3·0	21 14 41·7			,,
141				Internal contact	6 31 3·0	21 16 41·7			,,
142				External contact	9 29 28·5	0 15 7·2			,,
143	Aug. 1 9 30	T.	I Oc. D.	About bisected	9 31 7·5	0 16 46·2			,,
144				Disappeared	9 32 34·5	0 18 13·2	0 16		,,
145				External contact	6 36 38·4	21 22 17·1	21 23		,,
146	Aug. 2 6 37	T.	I Tr. I.	About bisection	6 38 19·9	21 23 58·6			,,
147				Internal contact	6 40 3·9	21 25 42·6			,,
148				External contact			22 19		,,
149	7 37	T.	I Sh. I.	Internal contact	7 36 23·8	22 22 2·5			,,
150				Internal contact	8 48 27·6	23 34 6·3			,,
151	8 50	T.	I Tr. E.	About bisected	8 50 30·6	23 36 9·3			,,
152				External contact	8 52 58·6	23 38 37·3	23 39		,,

Ref. No.												
153							Internal contact					,,
154			9	49	T.	I	Sh. E.	About bisected	9 46 57·0	0 32 35·7		,,
155								Limb complete	9 48 15·0	0 33 53·7	0 36	,,
156								First seen	5 58 6·5	20 43 45·2	20 45 23	+1 37·8 ,,
157	Aug.	8	6	0	R.	II	Ec. R.	Quite distinct	5 58 29·5	20 44 8·2		,,
158								Full blaze ?	6 0 39·5	20 46 18·2		,,
159								External contact	11 17 24·8	2 3 3·5		,,
160			11	20	T.	I	Oc. D.	About bisected	11 19 11·8	2 4 50·5		,,
161								Disappearance	11 21 15·8	2 6 54·5	2 4	,,

Remarks.

Ref. No.

133 Good.
134 Good.
135 Exact.
136 A little late; badly defined.
138 Good, but planet badly defined.
139, 140, 141 Very badly defined; not considered good.
142, 143, 144 External contact considered late; disappearance very exact. Planet and satellite well defined. The satellite disappeared behind and about the middle of the dark belt south of the equator. The dark belts on either side of the equator were hazy and seemingly covered with a thin cloud. The occultation was perfect at limb. No appearance of satellite as it passed behind the planet, but the Jovian clouds appeared denser than usual.

Ref. No.

145, 146, 147 Very steady, and times noted considered very exact. The dark belts appeared to be covered with a thin film of cloud, or as if seen through fog.
149 Good. *Vide* description and sketch.
153 Lost; late.
154, 155 Not good.
156, 157, 158 Good.
159, 160, 161 External contact (159) very good, disappearance (161) very exact; steady and well defined. The occultation perfect; satellite not visible through limb. The brown belts have still the hazy appearance noted on previous nights—as if covered with a thin film of cloud.

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
162				External contact	8 24 40·9	23 10 19·6	23 12		200
163	Aug. 9 8 26	T.	I Tr. I.	About bisected	8 26 51·9	23 12 30·6			,,
164				Internal contact	8 28 25·9	23 14 4·6			,,
165				First seen	9 28 17·8	0 13 56·5	0 14		,,
166	9 30	T.	I Sh. I.	About bisected	9 28 59·8	0 14 38·5			,,
167				Internal contact	9 31 23·8	0 17 2·5			,,
168	Aug. 11 6 10	T.	I Sh. E.	About bisected	6 9 54·4	20 55 33·1			,,
169				Limb complete	6 11 25·4	20 57 4·1	21 0		,,
170				External contact	9 24 38·6	0 10 17·3	0 11		,,
171	Aug. 13 9 27	T.	II Tr. I.	About bisected	9 27 12·1	0 12 50·8			,,
172				Internal contact	9 30 13·1	0 15 51·8			,,
173	Aug. 15 8 35	T.	II Ec. R.	First seen	8 35 8·1	23 20 46·8	23 22 25	+1 38·2	,,
174				Full blaze?	8 40 30·6	23 26 9·3			,,
175				Internal contact	7 6 7·5	21 51 46·2			,,
176	Aug. 16 7 10	T.	III Tr. E.	About bisected	7 8 48·5	21 54 27·2			,,
177				External contact	7 12 37·5	21 58 16·2	22 1		,,
178				First seen	8 56 55·8	23 42 34·5	23 45		,,
179	9 0	T.	III Sh. I.	About bisected	8 59 35·3	23 45 14·0			,,
180				Internal contact	9 5 27·3	23 51 6·0			,,

181						External contact	10 13 22·2	0 59 0·9	1 2			,,
182		10 16	T.	I	Tr. I.	About bisected	10 15 40·2	1 1 18·9				,,
183						Internal contact	10 18 19·7	1 3 58·4				,,
184						First seen	11 22 38·5	2 8 17·2	2 9			300
185		11 25	T.	I	Sh. I.	About bisected	11 25 0·0	2 10 38·7				,,
186						Internal contact	11 26 59·5	2 12 38·2				,,
187						Internal contact	10 48 8·6	1 33 47·3				200
188	Aug. 23	10 53	T.	III	Tr. E.	About bisected	10 51 34·1	1 37 12·8				,,
189						External contact	10 56 17·1	1 41 55·8	1 44			,,

Remarks.

Ref. No.
162, 163, 164 } Planet very tremulous and ill defined.
165, 166, 167 } Well defined; limb slightly indented when shadow first seen. The internal contact (167) considered good.
168, 169 } Well defined; internal contact lost; came too late to instrument.
170, 171, 172 } Not well defined; external contact (170) and bisection (171) fair, and internal contact (172) very good.
173, 174 } First seen as a mere speck; very good observation; well defined.
175 Late.

Ref. No.
177 Very good; well defined.
178, 179, 180 } Very good; well defined.
181, 182, 183 } Very good; well defined.
184, 185, 186 } Not good; definition wretched.
187, 188, 189 } Satellite steady, but limb of planet rather tremulous.

Ref. No.	Date and Time.	Observer.	Phenomenon.	Phase of Phenomenon.	Adelaide Mean Time. h m s	Corresponding G.M.T. h m s	Time by *Nautical Almanac*. h m s	Apparent Error of *Nautical Almanac*. m s	Power.
190				Limb indented	7 47 41·5	22 33 20·2	22 34		200
191	Aug. 25 7 50	T.	I Sh. I.	About bisected	7 48 32·5	22 34 11·2			,,
192				Internal contact	7 50 14·5	22 35 53·2			,,
193				Internal contact	9 57 15·7	0 42 54·4			,,
194	10 0	T.	I Sh. E.	About bisected	9 58 36·7	0 44 15·4			,,
195				Limb complete	10 0 11·2	0 45 49·9	0 50		,,
196	Aug. 26 7 23	T.	I Ec. R.	First seen	7 21 36·1	22 7 14·8	22 7 46	+0 31·2	,,
197				Full blaze	7 25 10·6	22 10 49·3			,,
198	Aug. 29 8 0	T.	IV Ec. D.				22 37 58		,,
199				External contact	8 29 2·1	23 14 40·8			,,
200	8 32	R.	II Oc. D.	About bisected	8 31 6·1	23 16 44·8			,,
201				Internal contact	8 33 59·9	23 19 38·6	23 18		,,
202				External contact	7 53 8·4	22 38 47·1			,,
203	Oct. 2 7 55	T.	I Oc. D.	About bisection	7 54 53·4	22 40 32·1			,,
204				Disappearance	7 56 51·4	22 42 30·1	22 41		,,
205				External contact			23 4		125
206	Oct. 10 8 20	T.	I Sh. I.	Bisected	8 19 6·0	23 4 44·7			,,
207				Internal contact	8 20 58·0	23 6 36·7			,,
208	9 23	T.	I Tr. E.	Internal contact	9 20 48·8	0 6 27·5			,,
209				External contact	9 24 55·8	0 10 34·5	0 8		,,

210	Oct. 11	7 50	R.	I	Ec. R.	First seen	7 49 31·8	22 35 10·5	22 35 22	+0 11·5	200
211						Full blaze ?	7 51 6·8	22 36 45·5			,,
212	Oct. 23	9 25	T.	III	Oc. R.	First seen	9 25 20·6	0 10 59·3	0 17		,,
213						About bisected	9 30 28·6	0 16 7·3			,,
214						Full blaze	9 37 22·6	0 23 1·3			,,
215	Nov. 4	7 47	T.	IV	Ec. D.	Half in shade	7 30 44·3	22 16 23·0			,,
216						Excessively faint	7 44 14·3	22 29 53·0			,,
217						Still visible	7 46 14·3	22 31 53·0			,,
218						Disappeared	7 46 35·8	22 32 14·5	22 26 30	−5 44·5	,,

Remarks.

Ref. No.

190 Late.

192 Good; planet unsteady.

193 Very good.

196 Very good.

198 The satellite never disappeared, but was reduced to a mere speck of light skirting margin of shadow.

199, 200, 201 Good; planet well defined and steady. The satellite disappeared behind the south dark belt, but was visible through the limb for about a minute after noted time of internal contact (201).

202, 203, 204 Not very good; planet ill defined and unsteady. The shadow of Satellite II indistinct.

205 Lost.

206, 207 Very good.

208, 209 Wretchedly defined.

210, 211 Planet very unsteady and ill defined; satellite when first seen quite distinct.

212 Supposed to be a little late. When the satellite was first seen it was sensibly separated from the limb or edge of planet, which, however, was not very well defined.

215, 216, 217, 218 Good; very steady. Planet and satellites beautifully defined; disks of latter distinctly visible. Progress of eclipse closely watched, and the instant of disappearance considered very exact.

Notes on the Physical Appearance of Jupiter etc.

1877.
June 30, 8^h. Looked at *Jupiter*. A black circular indentation on the edge of the bright belt, darker than the adjacent dark belt. The bright equatoreal belt is much broken up, and the two dark belts, especially the southern one, are marked by well defined bright streaks. The planet, however, was not very well defined.—T.

July 2, 8^h-9^h. The equatoreal bright belt appeared less dense and narrower than as seen on June 30, as though breaking up, especially near the meridian, where it was encroached upon by the dark belt to the south. The long narrow bright streak of cloud noticed on the 30th on the south dark band still visible, and certainly broader and better defined, extending from the east limb about three-quarters across the planet, tapering towards the west and having its base resting on the east edge of planet, where it merged into the bright equatoreal belt. Several remarkable darkish spots on the dark belts were visible, one near the western limb being the most marked; it was situated on the southern verge of the southern dark belt, and immediately to the east of it the adjoining southerly bright belt rose as a sharp bluff, like a cumulus cloud, as shown in the drawing; on the east side of the axis in the same belt, and to the south of the narrow bright streak before mentioned, was another dark spot; on the dark belt north of the equator, and to the east of the meridian, were several other darkish spots, of which the eastern one was the largest, and this at times appeared to extend partly across the equatoreal bright belt, giving one the idea, as it appeared and disappeared (owing probably to the variable definition or distinctness of the planet), of a flitting shadow, having apparently a pulsatory movement across the equatoreal belt. The dark belts do not appear to me to be so bright or to have the same metallic lustre as last year, being of a burnt-sienna colour and hazy. The drawing taken to-night is about $9\frac{1}{2}$ Jovian days after that taken on June 28.—T.

July 5, 9^h. Planet and satellites well defined; with powers of 300 and 600 both Mr. Ringwood and myself felt certain we saw a spot or mark near the centre of the third satellite.—T.

August 2, $8^h\ 10^m$. The definition good, but the planet had the appearance as if it was covered with a haze or fog; the clouds are not so brilliantly white, and the brown belts not so bright and lack the metallic lustre of last year. In the sketch (which is taken about 75 Jovian days after that of the 2nd July) there is shown a dark copper-coloured streak along the southern margin of the south brown belt, butting on to a bluff-headed streak of cumulus cloud which may be the same remarkable bluff head noticed on July 2. The north brown belt has a few scattered clouds in front of the shadow of the first satellite, as shown in the drawing. At $8^h\ 15^m$ it was noticed for the first time that there was a *faint* streak of cloud along the centre of the south dark band—perhaps the remnant of the narrow streak so prominent on July 2.—T. and R.

Oct. 23, $9^h\ 25^m$. At the occultation reappearance of the third satellite, when first seen, it was sensibly separated from the limb or edge of planet, which, however, was not very well defined.—T.

Total Eclipse of the Moon, February 27, 1877.

(Observer, Mr. Todd.)

Phase.	Adelaide Mean Time. h m s	Corresponding Greenwich Mean Time. h m s
Shadow first seen	14 44 17·0	5 29 56·0
„ bisecting Latronne	14 52 37·0	5 38 16·0
„ on east side of Tobias Mayer	14 55 57·0	5 41 36·0
„ bisecting Tobias Mayer	14 57 17·0	5 42 56·0
„ on west side of Tobias Mayer	14 57 26·0	5 43 5·0
„ bisecting Copernicus	15 3 25·0	5 49 4·0
„ touching east wall of Tycho	15 3 35·0	5 49 14·0
„ just over Copernicus	15 4 2·0	5 49 41·0
„ bisecting Tycho	15 4 17·0	5 49 56·0
„ bisecting Eratosthenes	15 10 52·0	5 56 31 0
„ on east wall of Archimedes	15 14 35·0	6 0 14·0
„ bisecting Archimedes	15 14 55·0	6 0 34·0
„ on west wall of Archimedes	15 15 20·0	6 0 59·0
„ on east wall of Manilius	15 17 19·0	6 2 58·0
„ bisecting Manilius	15 17 37·0	6 3 16·0
„ on west wall of Manilius	15 17 51·0	6 3 30·0
„ on east wall of Plato	15 18 2·0	6 3 41·0
„ bisecting Plato	15 18 35·0	6 4 14·0
„ on west wall of Plato	15 19 30·0	6 5 9·0
„ on east wall of Menelaus	15 20 24·0	6 6 3·0
„ bisecting Menelaus	15 20 50·0	6 6 29·0
„ on west wall of Menelaus	15 20 59·0	6 6 38·0
„ on east wall of Posidonius	15 27 32·0	6 13 11·0
„ on west wall of Posidonius	15 29 17·0	6 14 56·0
„ on east wall of Proclus	15 33 10·0	6 18 49·0
„ bisecting Proclus	15 33 35·0	6 19 14·0
„ on west wall of Proclus	15 33 53·0	6 19 32·0
„ on eastern edge of Mare Crisium	15 34 37·0	6 20 16·0
„ on western edge of Mare Crisium	15 38 57·0	6 24 36·0
Commencement of totality	15 42 4·8	6 27 43·5
About centre of totality	16 30 22·0	7 16 1·0
End of totality	17 18 13·6	8 3 52·3
East of shadow touching Damoiseau	17 18 42·0	8 4 21·0

Notes.

At $6^h\ 18^m$ G.M.T. the eastern limb was of a red coppery colour, which extended as far in as *Tycho* and *Copernicus*, where it gradually shaded off and changed to a deep greenish blue. At $6^h\ 22^m$ *Tobias Mayer* was very bright, and I could see all the diverging rays of *Tycho* as well as its prominent features and details. When totality commenced the red copper colour stretched right across the seas; about $7^h\ 0^m$ the outer red became more of an orange red, and the plains or seas appeared of a dark or black colour by contrast, the south pole having an orange, coppery, or rosy hue, whilst the north pole was still of a pale bluish green. At about centre of totality the south-east portion of the Moon was of a smoky orange red, extending over the whole of the Moon, leaving a fine yellow crescent round the north-west quarter, after which in the south-east portion the red became lighter and of a paler tint. At $7^h\ 30^m$ the yellow crescent was round the north pole, extending from west to east, the south-east portion becoming sensibly brighter; at $7^h\ 33^m$ the red colour was all round the south quadrant, more particularly about *Tycho*; at $7^h\ 38^m$ the north, east, and east-south-east limbs were of a light yellow colour, the western limb being very faint, and at $7^h\ 48^m$ was undiscernible.

General Description.

The total Eclipse of the Moon was observed here under most favourable circumstances. The sky was brilliantly clear, and the aspect of the heavens beautiful in the extreme.

The smoky reddish colour usually seen at lunar eclipses was well marked, but those portions of the Moon which passed through or near to the centre of the shadow were very dark, especially the plains or so-called seas, which appeared nearly black. The red colour was not very apparent until the shadow covered a considerable area of the surface, when all between and about the region of *Tycho* and *Copernicus* (over which the shadow passed almost simultaneously) was of a deep smoky red—brighter near *Copernicus*; whilst towards the advancing margin of the shadow, but within it, was of a greenish blue and yellow. The centre of the Moon passed through the northern portion of the shadow, and shortly before the eastern limb emerged, the western limb and round about *Mare Crisium* was near the axis or centre of the shadow and became nearly invisible; the eastern limb as it approached the edge of the shadow assuming the greenish yellow tinge of dawn, the north pole being similarly coloured, but separated by a dark gap from the illumination round the eastern and south-eastern limb, and the western limb becoming almost invisible, a horseshoe gulf of blackness extending inwards nearly half across the Moon.

Towards the end of totality, when the western limb was in the centre of the shadow, it became, as already stated, nearly invisible; I could not see it with a binocular fieldglass, and with the large telescope only by using a low power, the outline being then barely visible and the surface of *Mare Crisium* quite shut out. It may be remarked that at the time of central eclipse there was a sea horizon nearly all round, the Moon being in the zenith of a place on the Earth, the position of which is $74°\ 26'$ E. long.

and 8° 13′ N. lat.; the Atlantic Ocean immediately west of Africa therefore formed the horizon or bounding surface on the west and the Pacific Ocean immediately east of Australia on the east. It is not therefore improbable that the conditions for illumination were favourable; as a matter of fact, with the exception of the obscuration of the western limb and the darkness of the large plains when near the centre of the shadow, all the prominent features of the Moon were distinctly visible, especially the bright mountain *Aristarchus*, and even the diverging rays from *Tycho* and *Copernicus* could generally be seen.

During the Eclipse a number of Occultations of neighbouring small stars occurred. One only was noted, viz. a star of about the 10th magnitude, which disappeared at the north-east limb, at $16^h\ 47^m\ 3^s{\cdot}7$ A.M.T., corresponding to $7^h\ 32^m\ 42^s{\cdot}4$ G.M.T., appearing to hang on the dark edge of the limb, which was sharply defined, for two or three seconds.

Partial Eclipse of the Sun, February 2, 1878.

(Observer, Mr. Ringwood.)

The commencement of the Eclipse was well observed here with the 8-inch Equatoreal; the first surface reflection eye-piece, with a power of 67, was used. The first contact was noted at February 2, $5^h\ 42^m\ 35^s{\cdot}0$ Adelaide mean time, corresponding to February 1, $20^h\ 28^m\ 13^s{\cdot}7$ Greenwich mean time, and may be a second or two late. No spots were visible with power 120; the Moon appeared very black by contrast, but, when the Sun was out of the field of view, it was palely illuminated by Earth-light, no lunar features being, however, discernible; weather fine, passing clouds.

Observations of the solar thermometer were not taken, on account of the passing clouds, but the shade temperature was continually watched, nothing of importance being recorded.

Transit of Mercury, May 6, 1878.

(Observer, Mr. Ringwood.)

The Egress was observed here under very favourable conditions, the definition being very fair considering the low altitude of the Sun; the 8-inch Equatoreal, with the double micrometer eye-piece and a power of 140, was used. The Adelaide mean time of internal contact at egress was noted as May 6, $19^h\ 59^m\ 32^s{\cdot}1$ and the external contact as $20^h\ 2^m\ 36^s{\cdot}5$, corresponding respectively to May 6, $10^h\,45^m\ 10^s{\cdot}8$ and $10^h\ 48^m\ 15^s{\cdot}2$ Greenwich mean time; the egress took place at about 101° 42′ west of the north pole of the Sun.

When the planet was very close to the Sun's limb, which was

a little tremulous, the wavy surface appeared to touch the limb of the planet at times, and the time given of internal contact is when the continuity of the limb was first permanently broken and was considered very exact; there was nothing approaching the phenomenon of the black drop, nor was the planet at all distorted, though the slight boiling motion might (for the shortest possible moment) give one the idea of a fine line or hair joining the two bodies, but nothing definite or decided was seen. The planet was not in the faintest degree visible after passing off the Sun's disk. No sunspots were seen.

Meteor Showers derived from Foreign Observations: July to December. By W. F. Denning, Esq.

The showers given in the Table which follows were selected from a large number of such positions resulting from the projection of several thousand meteor-paths in the Catalogues of Heis, Weiss, Schiaparelli (1872), Zezioli, and Konkoly. They occur during the last half of the year and afford examples of well defined and active radiants, many of which will no doubt be frequently reobserved in future years. The list includes 79 of these meteor-streams, and 1,874 shooting stars were found conformable to them, giving an average of nearly 24 for each centre. The periods assigned are merely approximate. They relate simply to the dates for which the reductions were undertaken and afford no clue to the whole duration of many of the showers. Any extended references here to these newly ascertained centres are rendered unnecessary by the column of Notes affixed to them, in which many agreements and comparisons with old showers are specified; but in a few cases it seems desirable to add some particulars to what is already mentioned in the Table. The first group of reductions are for July 25–31, when the *Perseids* (No. 4) formed the most active shower and there were good contemporary radiants near θ *Persei* (No. 5) and β *Persei* (No. 3). The major shower of *Perseids* (near η *Persei*, showing a strong maximum on August 10) appears to continue certainly until the middle of September from precisely the same diverging focus as in July (compare Nos. 4 and 30 in the list). July also furnishes a good radiant close to ψ *Cassiopeiæ* which is well confirmed by Greg and Herschel and Heis, and further supported by a first magnitude stationary meteor observed by Billerbeck, at Rastenburg, on July 28, 1851, at $12° + 76°$, though the position is rather too far north. For August 6–12 there are some extremely well marked showers eastwards of the usual *Perseids*, several of which were already discovered by Heis in the years 1833–75, or by myself during a

number of morning observations in August 1877. The most noteworthy of these is a shower in *Camelopardus* (No. 14), near the stars *p*, *q* (of Bode), that had hitherto escaped discovery, though it is a rich and well defined radiant, which I have already referred to in the *Notices* (vol. xxxviii., p. 114), with maximum probably on about August 10. Another important system for the same epoch is given at *c Camelopardi* (No. 12), but this had already been seen by Heis and was independently found by me on the mornings of August 10–12, 1877. Mr. J. E. Clark, at York, also suspected a radiant here on August 10, 1871. The shower at 132°+77° (Nos. 10 and 21, July 25—August 12) appears to be a new position, and it is worthy of note that it falls exactly in the place of a strong October radiant. No. 22, at 74°+33°, is not quite certain as regards the exact point of radiation, which I suspect is a little further west, at 77°+32°. No. 33 is a prominent September shower well seen by me in 1877, September 4–15 A.M., at 61°+36° (15 ↓^{s}), and it agrees with two old positions determined by Schiaparelli (from Zezioli's observations) and Tupman, namely:—

S. & Z.	No. 147	Sept. 8	60+32	Mean at 63°+36°.
T.	No. 64	Sept. 7–15	66+40	

Of the autumnal showers the *Orionids* (No. 47), *Taurids* I (No. 41), and *Gemellids* (No. 40) of October supply the chief examples, but these have already been well investigated by Greg. It may, however, be said of the *Orionids* that they certainly continue until November 12, for a very exact radiant, coinciding with that shower, is shown there from the meteor-paths traced by Zezioli (see No. 70). As to the *Taurids* I (No. 41), the whole duration of the major radiant would seem to be from about October 12 to the first week in December; but there are several showers lying near together here, which it is necessary to dissociate. With this object in view I recently collected and compared all the observations of this system and found that, from 38 different determinations, there are probably *four* bordering showers of *Taurids* in October—November, as follows:—

I	At 62+21	Oct. 12—Dec. 6	21 radiants.
II	At 56+24	Nov. 1–13	6 radiants.
III	At 53+16	Oct. 6—Nov. 9	6 radiants.
IV	At 60+ 9	Oct. 10–22	5 radiants.

I is the major radiant with a sharply defined, persistent centre enduring apparently for 7 weeks. II is at the *Pleiades* (see No. 54 in the Table) and well observed by Greg and Herschel, Tupman, and myself, and at Greenwich. III appears equally certain. It was noted by Tupman in 1869 and by Backhouse in the same year. IV requires more observations, but

Schmidt's radiant at 62°+6°, October 10–22, and Tupman's, at 58°+10°, October 13, are perhaps sufficient to establish it beyond doubt, and its continuation in November is extremely probable, for Heis, at Munster, recorded a stationary meteor on November 13, 1869, at 58°+12°, and 38 other shooting stars converged on the same centre during the first half of the month. These several showers of *Taurids* should be carefully reobserved and the distinctive features of the meteors proceeding from them noted in each case. In the mornings of October—November the *Gemellids* (No. 40) also constitute a prominent shower. Gruber, from his October 17–28 reductions, places the centre at 109°·5+25°·2, October 22–27, and Schiaparelli and Zezioli, 113°+29°, for October 21–25, 1868 (56 meteors). This radiant was traced, as far back as 1839, by Herrick. Of the remaining October showers the most conspicuous examples are at 62°+47° (No. 45), 81°+23° (No. 35), 81°+54° (No. 34, *Aurigids*), and 86°+34° (No. 50). The former was chiefly deduced from the meteors in Weiss's catalogue and is verified by several other observations. No. 35 agrees in position with the *Taurids* II (No. 72), but the dates are too widely distant to allow an inference of connection. No. 34 is one of several contemporary showers of *Aurigids*. No. 50 was strikingly well seen by Zezioli on October 21, 1868 ($17\downarrow^{s}$), and this position, close to θ *Aurigæ*, is otherwise well supported as a prominent shower centre and separate from No. 39 at 78°+33°. For the first half of November the Table contains several good instances of morning showers, now satisfactorily determined for the first time. There is a rich stream at 142°+29°, near κ–μ *Leonis* (No. 61), accurately indicated by 31 paths and quite distinct to the *Leonids*. Schmidt saw this radiant at 140°+23° on October 19–27 and on the mornings of October 15–18, 1877, I traced a shower of swift, streak-leaving meteors (one of them stationary) from an exact centre at 140°+28°. The members of this stream have no doubt been confused hitherto with the *Leonids*, for the positions are close together and the phenomenon of streaks is a characteristic of the members of both systems. Schmidt's position for the new shower is about 5° too far south of the true centre, and it is rather remarkable that for December 9–12 there is also a good radiant at 143°+28°, which, agreeing so closely in place, seems merely a continuation of it. The other November showers given in the list are also very satisfactory and confirmed in nearly every case by Zezioli, Tupman, or myself during numerous morning watches in that month.

The *Taurids* II (No. 72) of December, with a strong maximum on about the 6th, had long escaped observation, appearing as they did at a time when the *Geminids* occupied attention, and there is little doubt that many of these *Taurids* were attributed to the wrong stream. A stationary meteor belonging to it was recorded by Bartel, at Brünn, on December 11, 1869, at 82°·9+22°·9, and this position, close to ζ *Tauri*, has been amply

confirmed by Greg and others. The shower in *Camelopardus* (No. 79), at 110°+70°, is a new one, but we require further observations before it can be safely regarded as established beyond doubt. The December showers, Nos. 73 to 77, in *Cancer*, *Leo*, and *Ursa*, agree very exactly with showers deduced for November (compare Nos. 62, 58, 63, 61, and 57); in fact it would seem, from a careful inspection of the observations, that these several radiant centres are in continuous operation from the middle of October to the middle of December! Yet such long duration is inadmissible on theoretical grounds, and to obviate the difficulty we have to assume a succession of distinct showers having, curiously enough, the same points of departure though no real connection exists between them. Whether the effects of planetary perturbations on these attenuated meteor streams is such as to diffuse them over a considerable epoch without sensibly altering the radiant points has yet to be ascertained; meanwhile observers will state the legitimate result of their labours apart from theoretical considerations, however incompatible they may at first appear.

A Synopsis of Old and New Meteor Showers (occurring during the last half of the year), derived from the Meteor Paths recorded in the Catalogues of Heis, Weiss, Zezioli, Schiaparelli, and Konkoly.

Ref. No.	Period of Shower.	Radiant Point. R.A. °	Dec. °	No. of ↓s	Observer or Authority.	Name of Shower or Approximate Star (Bode).	Remarks and Comparisons with previous Observations.
1	July 25–31 and Aug. 13	15	+70	35	H.W.Z. & K.	ψ Cassiopeiæ	12+70, July 7–Aug. 4, G. & H.; 15+70, July 28–29, H. Well seen in 1878, at 12+70, July 26–Aug. 2 (16 ↓s), D. *See* No. 56.
2	July 25–31	67	+66	14	H.W.Z. & K.	*c* Camelopardi	Beginning of No. 12; requires verification.
3	July 25–31 and Aug. 13	41	+40	28	H.W.Z. & K.	β Persei	38+38, July 31, 1856, Heis (stationary meteor). *See* No. 45.
4	July 25–31	45	+57	31	H.W.Z. & K.	Perseïds	Early members of the great August shower, with max. on 10th. *See* No. 30. Very few seen before Aug. 7, 1878, D.
5	July 25–31 and Aug. 13	32	+51	35	H.W.Z. & K.	θ Persei	37+48, July 19–Aug. 2, H.; 35+47, July, D. *See* No. 44. A very fine shower (63 ↓s) July 21–Aug. 1, 1878, at 32+53; maximum, July 30–Aug. 1, D.
6	July 25–31	23	+41	15	H.W.Z. & K.	γ Andromedæ	New shower. 23+41, July 29–Aug. 1, 1878, D. Compare with No. 32.
7	July 25–31	25	+57	23	H.W.Z. & K.	Cassiopeïds	Radiant diffuse and uncertain. 24+50, July 19–31, H.
8	July 25–31	13	+52	18	H.W.Z. & K.	Cassiopeïds	7+50, July, S. & Z.; 6+53, July, D. Seen also by Italian observers, 1872. 12+52, July 21–Aug. 1, 1878, D.
9	July 25–31	48	+73	14	H.W.Z. & K.	Custos	Beginning of No. 16. These several showers require more observation in July. They are already well established for Aug. 6–12.
10	July 25–31	130	+77	11	H.W.Z. & K.	29 Ursæ Majoris	Beginning of No. 21.
11	July 25–31	63	+50	10	H.W.Z. & K.	μ Persei	Beginning of No. 15.
12	Aug. 6–12	70	+64	74	S.H.W. & K.	*c* Camelopardi	70+65, Aug. 10–12, 1877, D.; 73+63, Aug., H.

13	Aug. 6–12	61+39	59	S.H.W. & K.	ϵ Persei	64+39, Aug. 11–19, H.; 61+43, Aug. 10, Parnisetti. *See* No. 49.
14	Aug. 6–13	96+71	106	S.H.W. & K.	*p*, *q* Camelopardi	A new and rich shower; the chief rad. E. of *Perseus*, Aug. 6–12. Slightly seen by D., July 30–Aug. 1, 1878. Meteors rather slow.
15	Aug. 6–12	61+48	59	S.H.W. & K.	μ Persei	61+48, Aug. 3–16, 1877, D.; 56+47, Aug. 3–11, Schmidt. *See* No. 45. The fireball of Aug. 11, 1876, had a radiant at 60+51 (A.S.H.)
16	Aug. 6–12	51+74	62	S.H.W. & K.	Custos	51+75, Aug. 6–12, H.; 50+75, Sept., G. & H. Compare No. 29. Seen also by D., July 26–31, 1878, at same point.
17	Aug. 6–12	78+56	59	S.H.W. & K.	δ Aurigæ	77+54, Aug. 11, 69, W.; early *Aurigids*. *See* No. 34. Stationary meteor seen by D. at 77+54, July 20, 1878.
18	Aug. 6–12	76+45	43	S.H.W. & K.	α Aurigæ	75+45, Aug. 29, 1870, T. Well defined radiant; 3 meteors stationary.
19	Aug. 6–12	50+47	42	S.H.W. & K.	α Persei	50+48, Aug. 3–12, Schmidt; 48+48, Aug. 6, 1869, T.
20	Aug. 6–12	92+57	42	S.H.W. & K.	δ Aurigæ	94+62, Aug., G. & H. Requires more observations.
21	Aug. 6–12	134+77	30	S.H.W. & K.	29 Ursæ Majoris	New shower. ? beginning of Heis's N_{15}, 130+84, Sept. Supported by 2 meteors, almost stationary, in July, on 21st, 1878, D.; and 26th, Strasser. *See* No. 10.
22	Aug. 6–12	74+33	28	S.H.W. & K.	φ Aurigæ	70+31, Aug. 29, 1870, T.; 70+32, Sept., Schmidt. *See* No. 39.
23	Aug. 6–12	104+34	13	S.H.W. & K.	θ Geminorum	110+32, Aug. 20–25, 1871, T. (suspected). Visible just before sunrise.
24	Aug. 6–12	99+45	17	S.H.W. & K.	Telescopium	A new radiant; distinct from the preceding. *See* No. 38.
25	Aug. 6–12	45+33	18	S.H.W. & K.	Musca	41+34, Aug. 10, S.; and Aug. 4, T. *See* No. 48.
26	Aug. 6–12	76+74	20	S.H.W. & K.	Camelopardus	Perhaps connected with No. 14; requires confirmation.

Ref. No.	Period of Shower.	Radiant Point. R.A. °	Dec. °	No. of ↓s	Observer or Authority.	Name of Shower or Approximate Star (Bode).	Remarks and Comparisons with previous Observations.
27	Aug. 6–12	52	+20	14	S.H.W. & K.	η Tauri	50+20, Aug.–Sept., 1871, Corder; 48+19, Aug. 10, Denza.
28	Aug. 6–12	87	+34	14	S.H.W. & K.	θ Aurigæ	A new Aug. shower; requires more observations. *See* No. 50.
29	Aug. 13	59	+70	10	H.W.K. & Z.	Camelopardus	Probably the same as No. 16. 59+70, Aug. 8–12, H.
30	Aug. 24–Sept. 14	45	+57	23	Z. & S.	Perseids	Late members of the August shower; radiant well defined.
31	Sept. 5–12	335	+47	9	Z.	Lacertids	334+48, Aug. 23, 1870, T.; same rad. as July–Aug. *Lacertids.*
32	Sept. 5–12	22	+45	13	Z.	γ Andromedæ	25+46, Aug.–Sept., 1877, D.; requires more observations.
33	Sept. 5–12	60	+37	9	Z.	ϵ Persei	No. 13 continued. A very good shower; seen by Z., T., & D.
34	Sept. 5–Nov. 12	81	+54	29	Z. & W.	δ Aurigæ	A long enduring shower, with diffused rad.; also Dec. 9–12, 80+50 (28 ↓s), D. and others.
35	Sept. 5–12 and Oct. 12–31	81	+23	30	Z. & W.	ζ Tauri	84+21, S. & Z., Oct. 13–21; perhaps two showers close together here? Active shower, 78+23, Sept. 8–10, 1869, T. *See* No. 72.
36	Sept. 8–Oct.	155	+41	13	Z.	μ Ursæ Majoris	154·5+41·5, Sept. 15–Oct. 18, 1877, D.; a good A.M. shower.
37	Oct. 12–13	5	+53	9	Z.	ζ Cassiopeiæ	5+53, Oct. 22–28, Schmidt; 5+55, October, G. & H.
38	Oct. 12–Nov. 7	98	+44	20	Z.	Telescopium	98+45, Nov. 1877, D.; also at 105+52, in October.
39	Oct. 12–31	78	+33	14	Z. & W.	ϕ Aurigæ	Sharply defined and exact; seen also by T., Oct. 13, 1869, and D., Oct. 8, 1877.
40	Oct. 12–Nov. 12	108	+24	50	Z. & W.	Gemellids	Rich shower seen by many observers; 105+27 (G., 1876).
41	Oct. 12–Nov. 12	62	+21	65	Z. & W.	Taurids I.	62+21, fireball of Nov. 23, 1877, T. A long enduring, rich, and well defined shower. N. of α *Tauri.*
42	Oct. 20–31	40	+21	18	W.	ϵ Arietis	43+22, Oct. 31–Nov. 1, 1877 (13 ↓s), D.; distinct from No. 48 *Muscids.*

43	Oct. 20–31	25+44	12	W.	γ Andromedæ	24+42, Oct. 17–31, 83 meteors, H. *See* No. 32.
44	Oct. 20–31	34+52	12	W.	θ Persei	32+50, Oct. 8, 1877, D.; exact and certain shower; meteors slow.
45	Oct. 20–31	62+47	31	Z. & W.	μ Persei	Strong radiant; seen at same point by D. (1877) and Italians (1872).
46	Oct. 20–31	40+40	22	W.	β Persei	37+38, Oct. 17–31, H. Compare with No. 3.
47	Oct. 20–31	92+18	64	Z. & W.	Orionids	Rich shower with strong max., Oct. 18–20. *See* No. 70.
48	Oct. 20–Nov. 7	42+31	24	Z. & W.	Muscids	39+30, Oct. 19, Gruber; 46+35, Aug. 22–Oct. 20, Greg.
49	Oct. 20–Nov. 12	62+37	21	Z. & W.	ϵ Persei	62+37, Oct.–Nov., Italian observations, 1872; 62+37, fireball, Nov. 6, 1869. (A.S.H.)
50	Oct. 21—Nov. 9–12	86+34	26	Z.	θ Aurigæ	Strong shower, Oct. 21, 1868 (Z.); 86+36, Nov. 7–10, 1876, Corder.
51	Oct. 19–27	300+55	10	W.	ψ Cygni	307+53, Nov. 1–13, Schmidt; not quite certain. A shower of bright meteors at 306+54 also on Sept. 1, D. and others.
52	Nov.	173+12	10	W.	β Leonis	A new radiant visible just before sunrise; requires further obs.
53	Nov. 1–7	120+40	9	Z.	Telescopium	125+40, Nov. 12, 1877, D.; exact and certain.
54	Nov. 1–7	56+23	11	Z.	η Tauri	56+24, Nov. 1–10, G. & H. & T. Distinct from *Taurids* I. (41).
55	Nov. 1–7	110+61	9	Z.	h Lyncis	Not certainly established. 111+65, Nov. 30, 1867, Z.
56	Nov. 1–7	15+74	7	Z.	f Cassiopeiæ	11+70, Oct. 8–14, 1877, D.; requires further watching.
57	Nov. 1–15	133+48	26	Z.W. & T.	ι, κ Ursæ Majoris	130+48, Oct. 21, S. & Z.; a well known shower; seen by many observers.
58	Nov. 1–15	149+38	23	Z.W. & T.	λ, μ Ursæ Majoris	142+36, Nov. 10–Dec. 9, S. & Z.; radiant not well defined.
59	Nov. 1–15	130+31	15	Z.W. & T.	ρ Cancri	133+31, Oct. 28–Nov. 13, 1877, D.; seen also by Schmidt in December.

Ref. No.	Period of Shower.	Radiant Point. R.A. °	Dec. °	No. of ↓s	Observer or Authority.	Name of Shower or Approximate Star (Bode).	Remarks and Comparisons with previous Observations.
60	Nov. 1–15	147	+22	26	Z.W. & T.	Leonids	A few stray members of the great periodical shower.
61	Nov. 1–15	142	+29	31	Z.W. & T.	κ Leonis	140+28, Oct. 15–18, 1877, D.; Schmidt also 140+23, Oct. 19–27. *See* No. 76.
62	Nov. 1–15	132	+20	17	Z.W. & T.	δ Cancri	133+21, Oct. 15–18, 1877, D.; a well marked shower. *See* No. 73.
63	Nov. 1–15	122	+14	13	Z.W. & T.	ζ Cancri	120+15, Oct. 15–18, 1877, D.; radiant sharply defined. A shower here also on Sept. 25, 1878, D. *See* No. 75.
64	Nov. 1–15	144	+52	14	Z.W. & T.	θ Ursæ Majoris	A shower also strongly suspected at 145+43.
65	Nov. 1–15	120	+23	16	Z.W. & T.	μ Cancri	Possibly a new radiant; requires further investigation.
66	Nov. 1–15	175	+32	8	Z.W. & T.	Coma Berenices	178+34, Oct. 16–17, 1877, D.; new shower in *Coma* just before daybreak.
67	Nov. 1–15	134	+ 8	12	Z.W. & T.	ζ Hydræ	134+6, December, G. & H.; radiant not very certain.
68	Nov. 1–15	142	+17	8	Z.W. & T.	ο Leonis	146+16, December, Schmidt; requires further watching.
69	Nov. 1–15	140	+62	13	Z.W. & T.	τ Ursæ Majoris	140+65, Nov. 8–Dec. 13, D.; stationary meteor seen by Billerbeck, 145+61, Nov. 13, 1852.
70	Nov. 9–12	94	+18	8	Z.	Orionids	Compare with No. 47. Late members of the October periodical shower. Radiant sharply defined.
71	Dec. 7–13	200	+67	9	W.	α Draconis	209+67, Nov. 25–Dec. 20, Corder, Denza, and D. A shower from this point also in Jan. and Feb.
72	Dec. 7–13	83	+23	27	W.	Taurids II.	A marked shower seen by D., Corder, and Sawyer, and confirmed by Greg; maximum Dec. 6.
73	Dec. 9–12	133	+19	10	W.Z. & H.	δ Cancri	Continuation of No. 62. Comet of 1680 ☄, 133+22, Dec. 27. 129+19, Dec. 21, 1876, D.

74	Dec. 9–12	152+43	16	W.Z. & H.	λ, μ Ursæ Majoris	149+45, Dec. 9–13, S. & Z. Compare Nos. 36 and 58.
75	Dec. 9–12	120+15	11	W.Z. & H.	ζ Cancri	*See* No. 63. These three showers, with the two preceding, apparently begin early in October and endure until about the middle of December. Radiation is sustained from the same points.
76	Dec. 9–12	143+28	10	W.Z. & H.	χ Leonis	*See* No. 61.
77	Dec. 9–12	134+50	11	W.Z. & H.	ι–κ Ursæ Maj.	*See* No. 57.
78	Dec. 9–12	178+46	10	W.Z. & H.	χ Ursæ Maj.	180+53, Dec. 12, S. & Z. A well defined shower.
79	Jan. 6–Feb. 16	110+70	26	Z.S. & H.	Camelopardus	Seen chiefly by Zezioli, Jan. 28. Requires further proof.

The abbreviations are—H., Heis (Observations from 1833–75; W., Weiss (Austrian Observations, 1867–74); Z., Zezioli (Observations at Bergamo, in Italy, 1867–70); S., Schiaparelli (Italian Observations, 1872); K., Konkoly (Hungarian Observations, 1871–76); G. & H. Greg and Herschel (British Association Observations, 1850–74); T., Tupman (Observations in the Mediterranean, 1869–71); and D., Denning (Observations at Bristol, 1876–78).

Account of additional Buildings and of Proceedings at the Oxford University Observatory. By Prof. C. Pritchard.

In the *Monthly Notices* for December 1873 and December 1875 I have described the buildings and Astronomical Instruments which the University of Oxford has provided for the use of the Professor of Astronomy. The results that have so far been derived therefrom may be understood from an inspection of the first issue of the *Astronomical Observations* and other astronomical work completed in the new Observatory during the first two years of its existence. Copies of this publication have been presented to the Society and to similar institutions.

At present we are earnestly engaged in measuring and reducing the measures of the Lunar Photographs which have been taken with all possible regularity for now nearly three years, with the De la Rue mirror of 13 inches aperture. The measures are made with a large but very delicate measuring engine, devised by Mr. De la Rue and executed with great precision by Mr. Simms. With care it is capable of measuring angular distances on the lunar photographs equivalent to one-tenth of a second of arc. Certain elaborate measures, and their subsequent numerical reductions, from their remarkable consistency of result, inspire me with the hope that we may in due time succeed in ascertaining the existence and approximate amount of the lunar physical libration. I propose, at the next meeting of the Society, to lay before them a short account of these preliminary measures and reductions; and I think they will be sufficient to show that careful photography is very effectively applicable to certain classes of astronomical investigations.

We have also made one complete set of measures of 40 stars in the *Pleiades* with my new duplex micrometer: this work is now in process of repetition, partly with the view of practically testing how far this instrument is capable of doing such work as is usually assigned to the heliometer; and partly with the view of ascertaining if any relative displacements in this group of stars have occurred since Bessel's celebrated measures of the *Pleiades* with the Königsberg heliometer in 1841. A general description of the principles and construction of this instrument will accompany the communication to the Society referred to in the last paragraph.

This evening I have contributed to the Society a few measures of the coordinates of Tempel's periodical comet at its apparition in July last: they were taken with the Grubb refractor of $12\frac{1}{4}$ inches aperture.

Such, then, is a general and rapid account of the researches completed and undertaken at the University Observatory since its erection three years ago.

My present object, however, is to acquaint the Society with another act of thoughtful liberality on the part of the University

towards the prosecution of the study of astronomy in Oxford. The buildings containing the large Grubb refractor and the De la Rue reflector, and comprising also two computing rooms, partly occupied by the huge piers supporting the instruments, contained no provision for the Professor's lectures to the University students. This want has now been very effectively supplied by the building, under the auspices of Mr. Charles Barry, of a convenient library and a well contrived lecture room, sufficient to satisfy all reasonable requirements. The dimensions of the lecture room are 40 feet by 27 feet, with a height of 18 feet. It is most amply lighted by five large windows having a northern aspect. The rooms and the entire Observatory are now warmed with hot water pipes; and the large instruments are effectually protected from the deposition of dew by the admission of warm air, at will, through large trapdoors in the ceilings of the rooms below; the trapdoors being provided with strong combings of latticework. With this exception, there is little or no novelty in the arrangements thus described.

But it occurred to me, while designing the large lecture room, that its roof might possibly be utilised for the formation of an out-of-doors or open-air Observatory, provided with suitable instruments for the instruction of the students, and for other purposes of original work. This design has been successfully carried out. The roof of the lecture room is flat and is covered with lead. Over this lead is placed a strong floor of battens with interstices between them for the passage of rain water. A somewhat high parapet extends on all sides above the roof, for the protection of persons upon the latter. Into the walls of the room have been inserted the ends of two very strong flitched beams with iron plates between them, and not touching the roof of the building. These two flitched beams are bolted together, and on them are placed massive stone slabs affording platforms for the telescopes to be placed upon them. These telescopes at present are two; viz. a refractor by Cooke of $4\frac{1}{4}$ inches aperture, and an exquisite reflector by With of $10\frac{1}{4}$ inches aperture. Both these instruments are practically free from tremor, even when many persons are assembled on the battened floor, and one or two standing on the beams. This is a degree of success in the mounting of instruments which I hardly ventured to anticipate: but so it is.

A third telescope of $3\frac{1}{2}$ inches aperture is placed on the leaded roof, but not in contact with the battened floor; this also admits of use without any tremor sufficient to annoy. A transparent drum of 2 feet diameter, revolving on an axis pointing to the pole, and containing the allineations of the principal stars, and lighted by a lamp within, completes the astronomical equipment of this somewhat novel out-of-doors Observatory. I ought, however, to remark that all these instruments are provided with light and easily removable housings to protect them from the weather. The roof also is well provided with gaslights for any temporary purpose.

Besides these astronomical instruments, there is placed on the parapet an efficient form of Campbell's globular lens for measuring and recording the duration, and to a considerable extent the comparative intensity, of sunshine during each day. This (to me, at least) interesting instrument I have covered with a thin cylindrical glass shade; and close to it is a radiation thermometer with a blackened bulb in vacuo. The instrument, *in this protected form of it*, is, I believe, a novelty not without its value; and hitherto its action has been admirable, inasmuch as it is very easy to read at a glance the duration of even any fitful sunshine during a succession of showers, within intervals of three or four minutes of time. By the side of it I have placed a Sun Spectroscope, for the observing of the "*Rain Bands*," together with a new and effective form of Daniells's hygrometer, designed by Mr. Bouillard, for comparison with the spectroscope in the forecasting of rain. Up to the present time the indications have been much to the advantage of the spectroscope. I can hardly doubt that these details of attempts to excite at least the curiosity of a large and important class of University students in subjects more or less astronomical, together with the account of the proceedings of our new Astronomical Institution at Oxford, will not be without their interest to many members of the Society.

I will only add that the Board of Visitors, at the head of which is the Vice-Chancellor, have sent in a recommendation to the University Commission for the furnishing of such funds and instruments as are necessary for the efficient maintenance of the Observatory. They also recommend the founding of a few astronomical studentships for the encouragement of the study of our science.

Oxford University Observatory,
Nov. 1878.

On the Spectrum of the New Star in Cygnus.

By T. W. Backhouse, Esq.

Soon after the appearance of the new star in *Cygnus*, and at various times since, I made observations on its spectrum with one of Browning's miniature spectroscopes on a Cooke's refractor of $4\frac{1}{4}$ inches aperture. With such small instruments accurate measurements have not been possible; and those I made must be taken for what they are worth.

I compared the spectrum of the star with those of vacuum tubes, of sparks in air, and of a Bunsen's burner; and from these observations I have calculated the positions of the bright lines on Huggins' scale. These are shown in Table I.; and the weight I attach to each observation is also given.

In Table II., Column A, these positions are reduced to wavelengths. My drawings of the spectrum show that these results cannot be all correct, and in Column B are given what I judge therefrom to be more accurate positions, and also those of two

lines that I only suspected. Column C gives Cornu's positions of the lines,* so far as they can be identified with mine; Column D gives Dr. Vogel's;† Column E, Dr. Copeland's, Jan. 1877;‡ and Column F, Lord Lindsay's, Sept. 1877. In Vogel's drawing of Dec. 8, 1876, all my lines are shown, except κ, besides a large number of others. The chief differences between my drawings and his of corresponding periods are the brightness in mine of δ and β and the feebleness of the diffused light next α towards β. Copeland's 456 and 414 are not certainly identified with mine.

Table III. gives the estimated relative brightness of the lines, that of γ being throughout taken as 1. A line given as ·5 is therefore one which I estimate to be half the brightness of γ, approximately. A query signifies a line merely suspected.

On July 24, 1877, γ was the only line visible, but there was much moonlight. On Aug. 8 I was almost sure of the existence of one line less refrangible than γ, and suspected another. On Nov 6 γ was the only line; but on the 29th I again suspected a line or two towards the red. On Dec. 7 γ was the only line.

I will add the following notes on the continuous spectrum.

1876, Dec. 28. Brightest from α to ϵ, especially about β and from γ to ϵ; also for a short distance after ζ, and again before η.

1877. On Feb. 12 I remarked that it had throughout remained brightest in much the same region, but that it was perhaps a little fainter in comparison with the bright lines.

March 14. Continuous spectrum very slight; it lies mostly on the least refrangible side of γ.

Aug. 8 and Nov. 6. A portion still suspected on the red side of γ.

Nov. 29 and Dec. 7. A portion suspected on each side of γ.

As the latter observations were made with the slit open to its widest extent, it is quite possible that some minute star may have been included in the field and so caused a continuous spectrum. It is undoubtedly the case that almost the whole of the light of the new star was then contained in the one bright line γ.

On February 2, 1878, I observed the spectrum by the method of simply placing a prism in front of the eye-piece of the telescope, when it appeared exactly like a star without the prism.

When I last looked for the star, on May 17, I found it was still fading, it being not certainly visible in the telescope; there were, however, both moonlight and twilight.

It must be understood that, though throughout this paper I have spoken of bright "lines" in the spectrum, they really appeared as points with my method of observing them—focusing the star on the spectroscope.

As regards the colour of the star, on December 22, 1876, it appeared white, but the observation was not favourably made. From December 27 to January 8 it was orange, at one time a deeper colour than 75 *Cygni*. On January 20 it appeared yellowish, but was getting too faint for its colour to be well distinguished.

* *Nature*, vol. xv., p. 158. † *Ibid*, vol. xvi., p. 400.
‡ *Ibid*, vol. xvi., p. 401.

TABLE I.—*Positions of the Bright Lines on Huggins' Scale.*

1876.	α	Weig	β	Weight.	θ	Weight.	γ	Weight.	δ	Weight.	ε	Weight.	ζ	Weight.	η	Weight.
Dec. 28	1005	5	1430	5			1750	10	1900	10	2050	10	2450	10	3370	5
,,	1060	5	1550	5	1710	5	1940	5	2085	5	2230	5	2640	5		
,,	1015	15	1550	15	1710	15	1950	15	2105	15	2260	15	2660	15		
1877.																
Jan. 8							1820	15			2075	15	2520	15		
19							2060	3								
20							2060	25			2325	25				
,,							1880	10								
25							1855	12								
Feb. 12	1140	8					1980	5			2165	6	2415	5	3425	5
,,							1940	10			2155	6	2595	10		
Mar. 14							2015	12								
,,							1995	12								
,,							2015	8								
,,	930	3														
15	1210	2														
,,	1045	5					1885	8								
,,							1765	8								
,,							1911	15								
May 15							1937	15								
,,							2015	10								
July 24							1934	20								
Dec. 7							1967	20								
Average	1049	43	1526	25	1710	20	1937	238	2033	30	2204	82	2557	60	3397	10

Table II.

Wave-lengths of the Bright Lines.

Line.	A. By comparison with other spectra. Backhouse.	B. By drawings. Backhouse.	C. Cornu.	D. Vogel.	E. Copeland.	F. Lindsay.
α	5831	5831	δ, 588	580		
?ι		?5630				
β	5333	5315	γ, 531	527		
θ	5183	5210	β, 517	514		
γ	5022	5022	ζ, 500	499	504	4986
δ	4960	4943				
ϵ	4858	4858	η, 483	Hβ, (486)	486	
ζ	4679	4660		467	?456	
?κ		?4590				
η	4367	4367	ϵ, 435	Hγ, (434)	?414	

Table III.

Relative Brightness of the Lines.

Line.	1876. Dec. 27.	Dec. 28.	Dec. 30.	1877. Jan. 2.	Jan. 8.	Jan. 17.	Jan. 19.	Feb. 7.	Feb. 14.	Mar. 14.	May 15.
α	·8	1·0	·8—	·45	·2	·17	·15	·12	?·1	·15	·1
?ι		?·1					?·02				
β	1·0	1·0	·8—	·4	·2	·15	·1	·12	?·1	·05	
θ		·5		·5							
γ	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0
δ	1·3	1·0	·8—	·6			?·02				
ϵ	2·5	2·0	2·0	1·7	·5	·6	·5	·3	·25	·25	·08
ζ	·8	·5	·8	·45	·2	·2	·17	·15	·15	·15	·06
?κ		?·1					?·02				
η	·2	·1		·25			·02	·08	?·1	·05	

Sunderland, June 3, 1870.

Measures of the Great B Line in the Spectrum of a High Sun.

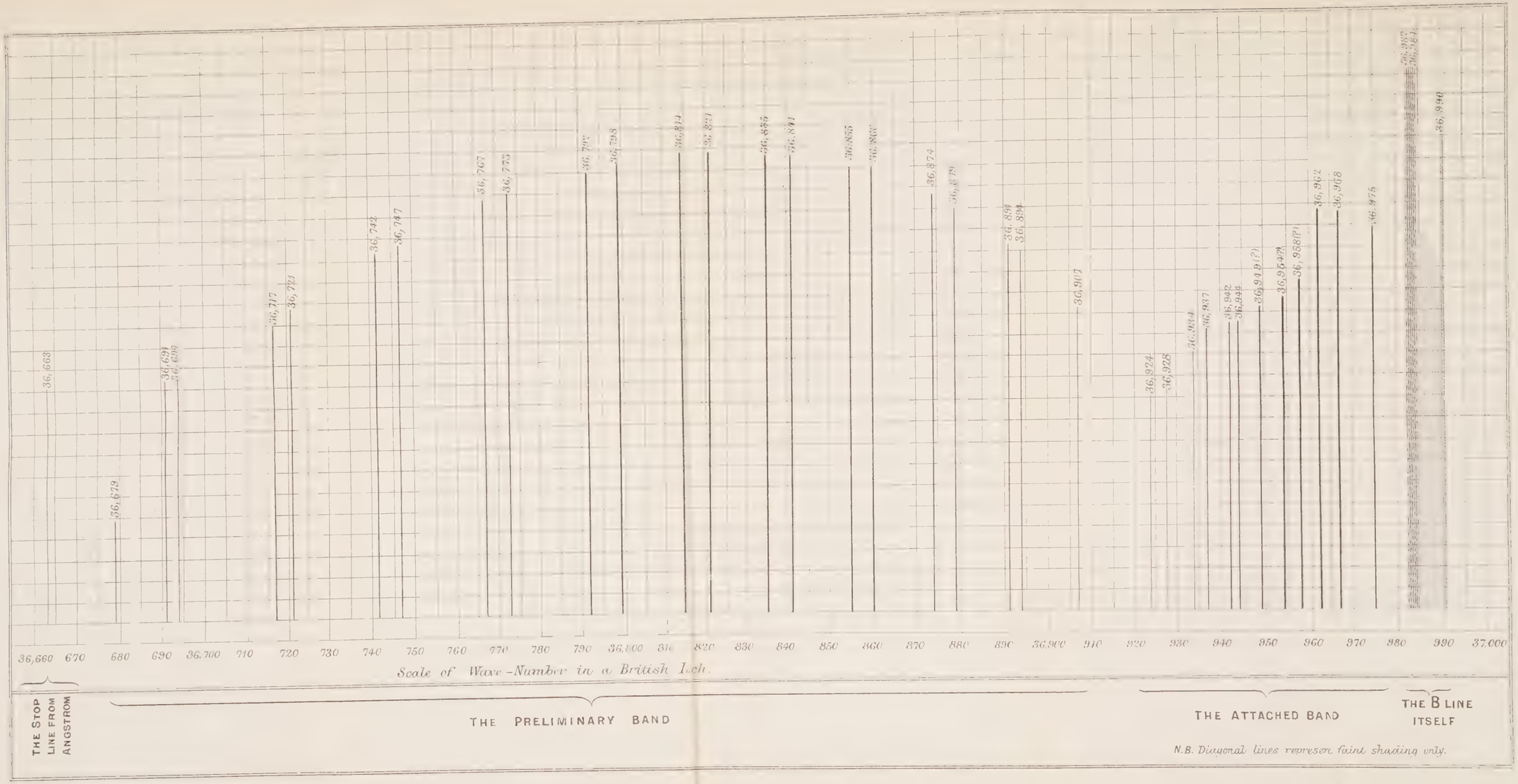
By Prof. Piazzi Smyth, Astronomer Royal for Scotland.

It is not known, I believe, as yet, by any direct experiment, to what chemical element, or elements, the B line in the solar spectrum is to be attributed. In its main part, if not also in its entirety, it must be of telluric, rather than solar, origin—because it is one of those lines which darken egregiously, and thicken also, when the C line of solar hydrogen does not, as the setting Sun approaches the horizon; a duplicate fact observed by me so far back as 1856, on the peak of Teneriffe. But it is more the *beauty* of the B line which has been of late dwelt on by observers possessing very powerful spectroscopes. "The most beautiful line in the whole solar spectrum" is a remark in one of his many optical papers by the accomplished Mr. Rutherfurd, of New York, probably the greatest master of line drawing and most consummate judge of geometrical symmetry and mechanical perfection in the whole world.

In what, then, does the alleged beauty of the said B line consist? I presume the answer will greatly depend on the degree of telluric development under which the line may have been viewed by each observer; always assuming that everyone means equally to express by "the line B" the whole congeries of lines forming both the attached band and the preliminary band to the actual line B; which, moreover, even in itself, is anything but a simple, single, line when in presence of still more penetrating examination.

Generally, however, and to all inhabitants of northern countries at least, where the Sun can never be observed very near the zenith, and therefore not through a zenithal *minimum* thickness of the Earth's atmosphere, the almost proverbial *beauty* of the great B line must consist in the rhythmical arrangement of the powerful lines forming the preliminary band to B and its attached band of finer, closer-set lines, or even linelets. Forcible, dark lines the former are, clean edged, well defined, no one of them exactly like another, either in thickness, or depth of colour, or distance from its neighbour on either side; and yet the whole forming a harmonious group, from which not one element could be taken away, and to which not one could be added, without introducing a discord and spoiling the entire system.

Such, I am quite aware, is *not* the manner of representation of the preliminary band of B, either for a high or a low Sun, in the Royal Society's second publication of such a spectrum as seen in the Himalayas; for they make it like a uniform fence of thin wires in one case, and of thick bars in the other. Nor is it like the unfortunate blotches which have unhappily resulted to Kirchoff's originally good spectrum map, from having latterly passed through many lithographic copyings, by hands adopting that method dangerous to all accuracy, of supplementing the imper-



THE GREAT B LINE AND ITS BANDS IN A HIGH SUN SPECTRUM; LISBON, JUNE, 1878.

(The lines are represented higher in proportion to their intensity.)

P. S. del.

fections of their first stone for black ink printing by other stones printing tints only, and seldom registering exactly. But my description does come very close to the admirable reproduction of B in Angstrom's normal solar spectrum; printed from stone also, but at one printing only, and from lines incised through a thin gum coating on the prepared surface of the stone, or rather into its very substance, and therefore as certain and secure as if engraved on a copper plate.

I had often admired the beauty of symmetry in Angstrom's "great B," and had seen something very like it when observing the solar spectrum last year at Cintra, merely with my aurora spectroscope; but what I saw then by no means prepared me for the transcending beauty of what beamed forth this year, with a better prepared solar spectroscope, and in the highest Sun which mid-day, at the summer solstice, could offer in Lisbon.

And pray what formed the beauty of the B line, then and there, do you ask? Unwilling to trust my own eyes alone, I asked my Wife to look into the telescope, and immediately came the exclamation, "Oh! the beautiful double lines!" Exactly so! each of the usually seen thick lines was now a double line, or rather showed two lines; so perfectly free from any filling up, even with the faintest haze, was the space between the components of any and every pair; while every line was so almost infinitely fine, but at the same time infinitely sharp, clear, and well defined on either side, and such perfect order and symmetry pervaded the whole arrangement, that it was a case *par excellence* of science and art combined.

With prism dispersions from 28 to 50 degrees between A and H, and a magnifying power of 20 on the telescope of inspection, the above features were abundantly distinct; and still further detail could, by careful attention, be made out in the closer system of the *attached* band of B.

This has always been rather a difficult subject. Wherefore in Brewster and Gladstone's enlarged view of B in the *Philosophical Transactions* for 1860, they show an anomalously large opening between the B line and its now so-called "attached band." While Angstrom, usually so trustworthy, and so powerful too at the red end of the spectrum, merely has a telluric shading, all but vanishing for a high Sun, and four single separate lines, of apparently foreign, though perhaps solar, character, in place of the attached band of B.

My published view of that band last year was confessedly imperfect and approximate only; but this year, while again establishing that there is such a band existing even in an almost zenith Sun, the earlier lines composing it were found to be a set of exquisitely close doubles, every one of them. While amongst the later ones were found some stronger single lines, partly confirmatory of Angstrom, and partly, from their greater distance asunder, confirming, or rather apologising for, the actual opening in Brewster and Gladstone's view.

Lastly, we come to the very B line itself; black and thick enough for anything in most plates published hitherto; but, in the highest Sun of Lisbon, shown to consist of a wonderful grouping of the finest possible lines. First a bundle of half a dozen or more, closely packed together into a shape like a Roman lictor's rod, so that, with smaller dispersion or worse definition, it would certainly be set down as a single, though clumsy and coarse, line; then a pale space, just indicating its composition of the feeblest, closest, and most uniform lines possible; and then a stronger line terminating the same space, and finishing off this marvellous and most compound arrangement spoken of so familiarly hitherto as merely "the great B line."

Seeing that the group—constellation almost—has such a decided and well marked physiognomy, and as the harmony and symmetry pervading all its lines of construction—except perhaps the few single lines seen in, or projected upon, the attached band—show it to be dependent on one element or elementary combination, and not to be the result of a chance coming together of stray lines from all sorts of alien elements scattered through the rest of the spectrum, I append both a record of my micrometer measures, though far from positively accurate, and a graphical representation; fervently hoping that by aid of it, notwithstanding its manifold imperfections, the chemists may one day succeed in finding a substance which, under *some* temperature or pressure, may present just such a picture, but in bright lines; and then there will be no sort of doubt at all, as to "what makes the great B line."

November 4, 1878.

Postscript.—(Nov. 22, 1878.)—Having received from Paris this morning a copy of the Second Edition of the late P. Secchi's *Le Soleil* (1875), I find at p. 285, vol. i., in his special "Description du spectre solaire," the following very apposite remark touching the chief subject of this paper:—

"Certaines bandes qui, dans les instruments ordinaires, paraissent comme estompées, sont en realité composées d'un grand nombre de lignes parfaitement distinctes, comme on le voit avec un spectroscope ayant un grand pouvoir dispersif; mais quelques-unes d'entre elles sont réellement diffuses sur les bords, et il est impossible de les décomposer, quelle que soit la puissance de l'instrument que l'on emploie. Nous pouvons citer comme exemple les raies du groupe B."

Hence it would appear pretty certain, though I have not been able to find in the book any account of direct and particular attempts to resolve the lines of B, that what was accomplished last June in Lisbon, and is detailed in the present paper, is happily more than that laborious and brilliant spectroscopist, the regretted P. A. Secchi, S.J., had himself seen, or even expected would ever be seen "in the group B" by anyone else.

Collected Micrometer Measures, reduced to Spectrum Place by Wave-number in a British Inch, of the Great B Line and its Bands, founding on Angstrom's Normal Solar Spectrum.

Object observed.		Rudely estimated Intensity.	Obs. of June 15, 1878, $10^h\ 30^m$ a.m. Dispersion 39°.	Obs. of June 19, at $11^h\ 50^m$ a.m. Dispersion 50°.	Obs. of June 19, at $0^h\ 30^m$ p.m. Dispersion 50°.	Concluded Mean for every Line.	Single Lines and Centres of Double Lines.	Differences. Width of Doubles.	Dist. of sides.	Dist. of centres.
Previous stop line, place assumed from Angstrom		1·5	36,663	36,663	36,663	36,663	36,663			
A very faint line		0·1			(36,679)	(36,679)	(36,679)		28	31
PRELIMINARY BAND.										
First pair, Component	1	0·5	36,690	36,689	36,692	36,691	36,692	3		
	2	0·5	692	692	695	694			23	27
Second pair, Component	1	0·7	36,715	36,718	36,718	36,717	36,719	4		
	2	0·7	718	721	723	721			21	25
Third pair, Component	1	1·0	36,741	36,742	36,743	36,742	36,744	5		
	2	1·0	746	746	748	747			20	26
Fourth pair, Component	1	1·5	36,767	36,766	36,768	36,767	36,770	6		
	2	1·5	773	771	774	773			19	25
Fifth pair, Component	1	1·8	36,793	36,790	36,792	36,792	36,795	6		
	2	1·8	800	796	798	798			16	22

Object observed.		Rudely estimated Intensity.	Obs. of June 15, 1878, $10^h\ 30^m$ a.m. Dispersion 39°.	Obs. of June 19, at $11^h\ 50^m$ a.m. Dispersion 50°.	Obs. of June 19, at $0^h\ 30^m$ p.m. Dispersion 50°.	Concluded Mean for every Line.	Single Lines and Centres of Double Lines.	Differences.		
								Width of Doubles.	Dist. of sides.	Dist. of centres.
Sixth pair, Component	1	2·0	36,817	36,812	36,814	36,814	36,817	7		
	2	2·0	826	818	819	821				
									14	21
Seventh pair, Component	1	2·5	36,840	36,833	36,834	36,835	36,838	6		
	2	2·5	848	839	839	841				
									14	20
Eighth pair, Component	1	2·5	36,860	36,854	36,853	36,855	36,858	5		
	2	2·5	867	858	858	860				
									14	18
Ninth pair, Component	1	2·0	36,879	36,874	36,874	36,874	36,876	5		
	2	2·0	884	878	878	879				
									12	16
Tenth pair, Component	1	1·5	36,897	36,890	36,889	36,891	36,892	3		
	2	1·5	900	893	892	894				
									13	15
Eleventh line, of Preliminary band, a Single one		1·0	36,912	36,904	36,906	36,907	36,907			
									(17)	(19)
Attached Band.										
First pair, Component	1	0·3	36,923	36,923	36,925	36,924	36,926	4		
	2	0·3	927	927	930	928				
									6	10

Second pair, Component	1	0·5	36,930	36,933	36,937	36,934	36,936	3	
	2	0·5	934	936	940	937			5 7
Third pair, Component	1	0·8	36,939	36,943	36,944	36,942	36,943	2	
	2	0·8	944	945	946	944			5 8?
Fourth pair?		1·0	36,949	36,950	36,949	36,949?	36,951?		
Fifth pair?		1·0	36,955	36,953	36,953	36,954			5? 5?
Sixth pair?		0·8		36,957	36,958	36,958	36,956?		4? —
A strong single line		2·0	36,961	36,962	36,962	36,962	36,962		4?
Another ditto		2·0	36,968	36,968	36,968	36,968	36,968		6 6
Another fainter		1·5	36,975	36,975	36,974	36,975	36,975		7 7
									(7) (8)
B Line.									
First side of bundle		3·0	36,984	36,983	36,982	36,982	36,983		2
Second ditto					984	984			
Pale space begins					36,984	36,984			7
Ditto ends					988	990			
Terminal line		2·0	36,994	36,990	36,988	36,990	36,990		

Some Remarks on the Total Solar Eclipse of July 29, 1878.

By Arthur Schuster, Ph.D., F.R.A.S.

I venture to lay before the Society a few results which I have obtained during the recent total solar eclipse in Colorado, and also some theoretical considerations, which I hope may help in the discussion of other observations.

I was stationed at West Los Animas, the capital of South Colorado. The telescope, with a $4\frac{1}{2}$-inch objective, belonged to Colonel Campbell, of Blytheswood, and my best thanks are due to him for his generosity in placing the instrument at my disposal. The spectroscope had a single prism of dense white flint.

Several hours before the eclipse I covered my left eye, which I intended to use during the eclipse, with a piece of black velvet; all observations before totality were made with my right eye. The enormous extent to which the eye is rendered more sensitive by being kept in the dark is seldom realised. Half-an-hour before the eclipse I uncovered the eye for a few seconds. A sheet of white paper which to my right eye looked a dull white, appeared so dazzling to my left eye that I could not bear to look at it.

I watched the solar spectrum as the Moon gradually began to cover the solar disk, and I was greatly struck with the fact that the violet lines came out so very much more clearly than I ever remembered having seen them under the same circumstances. Although at the time I considered this an apparent effect due to the fact that the general illumination was diminishing and the eye becoming more sensitive, it was so striking that I continued to make notes on the subject until ten minutes before totality, when I could see beyond K. After the end of totality Prof. Eastman told me that he was struck by the great distinctness of the violet lines before totality, and Prof. Young mentions, in the account of his observations, that ten minutes before totality he could, with a fluorescent eye-piece, see dark lines quite to O, and rather better than before the eclipse began. I cannot now consider that this fact, which was so conspicuous as to have struck three independent observers not looking out for it, was simply due to an effect of contrast. In my own instrument, for instance, the general illumination had little to do with the visibility of any lines. It is the intensity of the rays in the blue which weaken the sensitiveness of the eye for the violet, and the intensity of these rays did not decrease as the eclipse proceeded.

I believe I can offer an explanation of the phenomenon. It is well known that under different atmospheric conditions, which even apparently may be alike in every other respect, the

blue end of the solar spectrum is sometimes very vivid, sometimes not visible; and it is easy to imagine that the cooling effect of the eclipse should produce the change from one of these atmospheric conditions to the other. We know, for instance, that aqueous vapour absorbs the violet rays; on the other hand water is, after quartz, the most transparent substance for the ultraviolet. If we assume that the cooling which takes place during the eclipse condenses part of the aqueous vapour, it would follow as a natural consequence that the violet rays should come out more distinctly.

Ten minutes before totality I began to watch the eclipse, in order to see whether the corona was going to be visible before totality. I looked through one tube of an ordinary opera glass; but totality was close at hand before the corona was visible. A chronometer was standing close by me, and I began to count seconds from the time I saw the corona up to the time the last ray of the sun disappeared. I counted six seconds. I then went to my spectroscope, which previously had been pointed to the violet end. My friend, Mr. Haskins, Fellow of St. John's College, Cambridge, was at the finder, and we had previously agreed that unless he saw a large prominence he should point the telescope to the brightest part of the corona. He pointed it to the corona, and I was struck by the intensity of the continuous spectrum. I could see into the violet as far as wave-length 4070, which is further into the violet than the hydrogen line *h*. Widening or narrowing the slit seemed to have no appreciable effect on the limit of the spectrum. I then asked Mr. Haskins to point the telescope to a point further removed from the Moon, and he accordingly pointed it to a part which was three-tenths of the lunar diameter away. I could see no change in the intensity of the spectrum. I next moved the telescope of the spectroscope into the green, and was at first sight startled by not seeing the green line. Looking again at the place, I thought I could discover two faint lines,* but before I could register their position the bright chromospheric lines appeared, and remained for several seconds after the Sun had reappeared.

I saw no dark lines crossing the continuous spectrum. That these dark lines existed I have no doubt, from the observations of Profs. Barker and Morton, who observed in Dr. Henry Draper's party. Yet others beside myself have not seen the dark lines, and I consider this strong evidence that only part, and perhaps only a small part, of the continuous spectrum is due to reflected sunlight.

The polariscope is likely to give us information as to the proportion of scattered light in the corona. I have calculated the amount of polarization due to the scattering of a particle illuminated by a spherical surface. The whole light scattered from such a particle can be divided into two parts. One part

* Prof. Eastman tells me that he suspected a green line more refracted than 1474 K.

is equal to that which would be scattered by the particle if a source of light shining with an intensity

$$\pi S r^2 \cos \omega$$

were placed at the centre of the sphere; the other part is equal to that which would be sent out by the particle itself, if it was luminous and shining with an intensity

$$\frac{2\pi}{3} AS (2 - 3 \cos \omega + \cos^3 \omega).$$

In these expressions S is the intensity of the light sent out normally by the unit surface of the sphere; ω is the angle subtended at the particle by a line drawn to the centre of the sphere and a tangent to the sphere; A is the proportion of the light scattered by a particle in any direction if the incident light is polarized in a plane containing the incident and scattered ray; r is the radius of the luminous sphere. If we decompose the scattered light into two components, one polarized in a plane passing through the Sun's centre, the other at right angles to it, the proportion of the second component to the first will be

$$1 - 3 \sin^2 \phi \frac{\cos \omega + \cos^2 \omega}{4 + \cos \omega + \cos^2 \omega}.$$

In this expression ϕ is the angle subtended at the particle by the Sun's centre and the scattered ray.

It appears from these expressions that close to the surface of the Sun, where ω is a right angle, the light scattered from a particle is entirely unpolarized; that as the particle is removed from the Sun, the polarization in any direction increases, until finally, when the particle is at an infinite distance, ω vanishes and the polarization is complete in a direction normal to the incident ray. The polarization therefore ought to increase as we go away from the Sun. I have only taken a single particle into account. As the line of vision directed to the edge of the Sun will pass through particles which are away from the Sun, the light even in this direction will be polarized; but in any case the polarization ought to increase as we go away from the Sun.

These theoretical considerations teach us the amount of polarization in light scattered from a certain fixed number of particles placed at different distances from the Sun. If we could combine with this an accurate measurement of the percentage of polarized light actually sent out by the corona, we should be able to determine the relative number of scattering particles at different distances, and also the proportion of scattered light to the light due to the incandescence of the particles and other causes, such as ordinary reflection. That we should in this way gain most important information will be obvious to everybody.

As a matter of observation the amount of polarization seems first to increase with the distance from the Sun, reach a maximum, and then to decrease rapidly. The maximum of polarization was first observed by Mr. Prazmowski during the

eclipse of July 1860. It was confirmed by Janssen in 1871; and during the same eclipse Mr. Winter took two measurements, one close to the Sun and one a few minutes away from the Sun. The polarization at the latter place was half as much again as close to the limb of the Sun. During the recent eclipse Prof. Arthur Wright took a series of very careful measurements, but only began a few minutes away from the Sun. He observed a rapid decrease as the distance increased. The reason why the polarization close to the Sun is smaller than at a distance of a few minutes is obvious from our theoretical discussion. The fact that a maximum is reached after which the polarization rapidly decreases admits of only one explanation: that the particles begin to be too coarse to polarize the light in the act of scattering.

The exact determination of the point of maximum polarization must in future form one of the most important parts of eclipse observation. A variation of this distance during different eclipses, which will probably be observed, will lead to important conclusions.

There is one more point to which I wish to draw the attention of the Society. It is well known that during the eclipses of the last few years the Sun's corona was found to be approximately symmetrical round an axis which has been designated sometimes as the axis of the Sun, sometimes as the axis of the ecliptic. The two are inclined at an angle which, as seen from the Earth, varies between over 7° 15′ and nothing. If the corona is of cosmic origin, there is no reason why the corona should be drawn out exactly in the ecliptic, though there may be reason that it should be drawn out approximately in the ecliptic. On the other hand, if the corona is a solar atmosphere, the symmetry should be round the axis of the Sun. It would be a matter of interest to mark on drawings and photographs of the corona not only the Sun's equator, but also the ecliptic. The inclination of these two lines during the eclipse of 1871 was more than 7°. A cursory examination of Colonel Tennant's photographs has led me to think that during that eclipse the corona was symmetrical neither exactly round the solar axis nor round the axis of the ecliptic, but nearer the former than the latter. The point which I wish to bring forward, however, is not this symmetry, but a variation from symmetry which is nearly always observed. The corona has generally been found to be drawn out more in one direction than in another diametrically opposed to it, and the remarkable fact is that the eclipses of 1874 and 1875, which happened at an interval of very nearly a year, so that the Sun and Earth were nearly in the same relative position, resembled each other not only in general features, but also in the fact that the corona was developed more towards the north than it was towards the south. That this fact has some meaning I have no doubt, but what this meaning is can only be made out by a careful examination of the outlines of the corona as seen from different relative positions of Sun and Earth.

The Total Eclipse of the Sun, July 29, 1878.

By F. C. Penrose, Esq.

In company with three members of this Society and some others, I embarked on board one of the steamers of the White Star Line (the Germanic) and afterwards proceeded, with the larger portion of the party, to Denver, in Colorado, for the purpose of observing this eclipse. I took up a position on the outskirts of Denver, in N. latitude 39° 46′ 29″ and W. longitude 105° 1′ 43″, as ascertained by triangulation from a standard point in Denver, the altitude above the sea level being about 5,500 feet.

The threatening weather of the eight days previous to the eclipse had pointed out the propriety of the observing parties being separated, and this we had done to some extent. Mr. Ranyard was with Professor Young about 5 miles distant and Mr. Loder and his party were at an intermediate point in Denver itself. I was assisted by Mr. Baldwin, a young gentleman of Denver who had been introduced to me through Professor Young. I used a $2\frac{1}{4}$-inch achromatic by Troughton & Simms, with power 30 and field of view 74′.

My principal object was to draw the corona, but I also endeavoured, so far as it did not interfere with my main purpose, to note the time of the four principal phases. In this I partly succeeded; but, owing to the hurry which resulted from having to rearrange some defences against the wind, which was blowing rather fresh, I did not get a good observation of first contact. The wind fell as the eclipse advanced, and nothing could be more favourable than the atmospheric conditions. My observation of second contact was better, but I consider it uncertain to about two seconds. As for the two last, I have no reason for supposing them to be more than a second in error.

	Locat. M.T. h	m	s
First contact	2	19	29·4
Second contact	3	28	51·5
Third contact	3	31	35·6
Fourth contact	4	34	49·6

As totality approached I was much struck with the shortness and apparently equal width and blunted ends of the diminishing remnant of the photosphere. I saw no sign of Baily's beads, and the white light was extinguished at once, like a gas lamp turned off suddenly. I withdrew at once the grey screen I had been using and saw the rosy tints of the chromosphere and immediately afterwards the silvery corona.

My companion called the time during the first minute, during which I passed the scale which I had in the eye-piece completely round the Moon, and ascertained that I could trace the extent of the corona for 28 minutes of arc in the direction of the ecliptic

eastwards, and nearly as far, but not quite, in the opposite direction, but nowhere else so far. I then made some pencil records of the streamers of the corona and occupied myself during the short remainder of the time in studying its (true) northern half, and in the drawing whatever is shown of this half

should have more weight attached to it than to the other. I took but little notice of the prominences, but could not help observing a bright hooked one which appeared to me to shoot out towards the east not long before totality ended. I believe some other observers noticed two hooked prominences in the same neighbourhood.

Almost directly after totality had ceased I left the telescope to the care of my companion and went aside and made a coloured drawing of what I had just witnessed, and it is from this rough sketch and the lines drawn during totality that the drawing has been composed. I have, however, added to it, in a paler tone of colour, some features which have been supplied to me by Professor Cleveland Abbé and which has been confirmed by other observers, namely Mr. Lockyer, who observed

during part of the time, and Dr. Edmunds, of Denver, who observed throughout with the naked eye and saw streamers at a much greater distance than could be seen in the telescope, of the similitude of a wind vane. I looked up for about a second without the telescope and saw nothing but the intensely black Moon surrounded, or nearly so, with a rosy garland apparently of much greater width than the sierra had appeared in the telescope, but I did not look long enough to get my eye into focus. Professor Abbé has described these streamers as having, in his opinion, a meteoric origin, and I have made a diagram which shows that none of the lines which either these observers or I have recorded is inconsistent with this view.

The pointed ends of the "wind vane," of which I have given the observed lines in red, seem to favour the explanation of an elliptic orbit of considerable major axis and great excentricity, such as would fall in with the blue lines. The wedge-like point proceeding from the north pole of the Sun would agree with a similar figure, whilst some of the others can be explained by orbits of meteors of less extent. It is obviously not requisite that the Sun's centre should be the focus of the apparent orbit, as it would be modified from the real figure by perspective. The red lines on the diagram, with the exception of those belonging to the "wind vane," are all of them enlargements of the lines which I mapped down during totality, without having any idea or theory of the possible meteoric origin of the corona; which, however, both the spectroscopic and eye observations seem to combine in rendering probable.*

I am far from arguing that this theory answers for the whole of the corona, and I much doubt whether it will explain the almost equal and radial lines which proceeded from the neighbourhood of the Sun's north pole, and which appeared to me the most beautiful part of the whole. There was also something analogous near the Sun's south pole, but not so clearly radial. I did not, however, examine this part so closely. The rays proceeding from the north pole seemed of a rather warmer colour than the rest of the corona, and I thought, but am not

* For want of space the woodcut does not give the more distant streamers &c. referred to in the text as seen by the naked eye, but is confined to my own observations: neither does it attempt to represent the blackness of the Moon. In the drawing I found it necessary to embody the particulars referred to for the purpose of giving a truer rendering of the background upon which I saw the corona projected. I had myself noticed and recorded during totality that it seemed to shade off imperceptibly in the direction of the solar equator, both east and west, whilst its termination was more clearly defined in other directions: a uniform ground therefore would not have been correct.—F. C. P.

The diagram referred to in the text, as well as the drawing showing the additional streamers observed by Prof. Cleveland Abbé, Mr. Lockyer, and Dr. Edmunds, can be referred to at the Society's apartments.—Ed.

sure, that there was some slight movement or palpitation at their extremities.

In the eastern part of the corona there seemed to be, but only faintly, some signs of dapplings of a darker grey than the rest. Were these perhaps meteor streams seen from the Earth in section and so rather intercepting the light of the more luminous parts? It will be remembered that, judging from the analogy of the November meteors, these bodies may not be uniformly scattered in their orbits, and it may easily happen that the part where the meteoric bodies are thickest may be too far from the Sun to receive much illumination. Just after the reappearance of the Sun several serpentine fringes were seen moving southwards along the ground, at no great distance apart and at an estimated pace of about 5 miles an hour, and about 8 inches broad. They were brown themselves, but the light between them was of a golden hue.

I must not conclude without a word of recognition of the kindness we received from the American astronomers, of the liberality of the railroad authorities of the United States, and the co-operation of the company and officers of the White Star Line of steamers.

November 1878.

On the progress of the Reductions connected with the Ascension Expedition. By David Gill, Esq.

I beg to submit to the Society the following report on the observations of *Mars* made at Ascension.

1. The observations for time, made with the 30-inch transit instrument by Cooke, belonging to the Society, have been reduced. Time was determined, as a rule, each second or third day, and by comparisons at the time the error of each of the five chronometers was ascertained.

The error of the chronometer used when observing *Mars* was then deduced for intermediate intervals from its comparison with the stationary chronometers, and thus four independent determinations of its error before and after each series of observations were obtained. On no single occasion, however, do the results so obtained differ half a second from the interpolated rate of the observing chronometer.

2. The observations of the Sun, made at St. Helena and Ascension with the reflecting circle, to determine local time, are also reduced; the following are the results for difference of longitude:—

Ascension west of St. Helena.

		Without Temperature Corrections. h m s	With Temperature Corrections. h m s
By Chronometer	B	+0 34 46·61	+0 34 46·19
	C	48·04	47·89
	E	41·94	43·46
	F	46·05	45·91
Mean		0 34 45·66 ± 1ˢ·02	0 34 45·86 ± 0ˢ·61

The results in the left hand column were obtained in the ordinary way by adopting for the rate at sea the mean of the rates determined before and after the voyage, at St. Helena and Ascension respectively.

The results in the right hand column were obtained by the application of corrections for temperature, the coefficients for each chronometer having been determined from trials made by Mr. Hartnup at Liverpool. The temperature was determined by chronometer D, an uncompensated chronometer, acting as a chronometric thermometer. The introduction of the temperature corrections diminishes the probable error of the result by nearly one-half. The observations at St. Helena were made on the steps of the principal entrance of Johnson's Observatory; the observations at Ascension at a small pillar in Garrison, built for the convenience of navigating officers and their observations for time.

The original site of the Transit Hut in Garrison was 16 feet to the east and 160 feet to the south of this pillar. But all the observations of *Mars*, excepting those of July 31, were made not in Garrison, but at Mars Bay. Accordingly, after the observations at Mars Bay were finished, the difference of longitude between Mars Bay and Garrison was determined by chronometers, as follows:—

	h m s s
Mars Bay W. of old Magnetic Observatory in Garrison	−0 0 3·29 ± 0·23
Old Magnetic Observatory W. of observing pillar 502 ft.	−0 0 0·37
Observing pillar W. of Johnson's Observatory, St. Helena	+0 34 45·86 ± 0·61
Mars Bay (Transit Hut) W. of Johnson's Observatory	+0 34 42·20 ± 0·66
Johnson gave for longitude of his Observatory	+0 22 54·60
Hence, according to Johnson, Mars Bay W. of Greenwich	0 57 36·80

Only 3 occultations were observed at the dark limb of the Moon at Mars Bay. These were reduced, employing Newcomb's corrections to Hansen's Tables of the Moon, and recent Greenwich observations of the occulted stars, kindly communicated by the Astronomer Royal. The results for longitude are

		h	m	s
Sept. 14	By disappearance of B.A.C. 6063	0	57	44·80
Sept. 18	„ disappearance of 31 *Capricorni*	0	57	40·08
Oct. 3	„ reappearance of ρ *Leonis*	0	57	39·87

I have adopted provisionally

	h	m	s
Mars Bay (Transit Hut) W. of Greenwich	+0	57	39
Garrison „ „	+	57	42

As a rigid determination of the tabular errors of *Mars* was one object I had in view, further means were taken to secure a satisfactory longitude. A number of Moon culminations were observed with the transit instrument, and a number of distances of the Moon from stars were measured by means of the heliometer.* The latter, I believe,will give results of great accuracy if I can succeed in satisfactorily determining the errors of the Lunar Tables. I have received the Greenwich and Strasburg observations, but wait those of Washington and Paris. The lunar distances measured by the heliometer are also available for testing how far it will be possible to apply the diurnal displacement to the determination of the lunar parallax. I believe it will be fonud to be the best of all methods for determining this important constant.

Since a small error in the adopted longitude does not in any way affect the resulting solar parallax, and since the correction for an error in longitude can be applied at the end to the resulting tabular error, I intend to postpone the further discussion of the longitude till the other more important results are completed.

3. The latitude was determined in the first place by Talcott's method. The micrometer of the transit instrument was turned round 90°; and so, by its means, the difference of zenith distance of two stars, culminating on opposite sides of the zenith, was observed. The level of the setting circle, however, was far from sensitive, and I could not succeed in substituting for it a more sensitive bubble. I tried to attach the bubble of the cross level to the setting circle, but could not succeed, with the appliances at my disposal, in making the attachment rigid enough to bear reversal and re-reversal with consistent results.

* I must here express my obligations to our Fellow, Mr. Penrose, for the admirable charts he constructed for me, by which I was able to make the observations referred to. By methods he has already explained to the Society, he laid down graphically the apparent path of the Moon at Ascension, and the apparent places of the stars within reach of measurement. From these charts the distance and position angle of the Moon from neighbouring stars could be read off with all the accuracy required for setting. By similar methods he predicted the occultations of all stars of the *Nautical Almanac* list which would be visible at Ascension on the nights I was at liberty to observe them.

By taking great pains to bring up the bubble to the same point, in the same way opposite sides of the zenith, I made the best observations I could. On the last night at Mars Bay I removed the roof of the Transit hut, and observed stars in the prime vertical. The results, from both methods, proved on reduction to be much more accurate than I expected, and both gave for the geographical latitude

$$\begin{array}{ccc} ^{\circ} & ' & '' \\ -7 & 59 & 15{\cdot}5. \end{array}$$

4. The tabular quantities have been computed as follows:—

(1) The geocentric apparent places of *Mars* for each day at Greenwich mean noon were computed with all the accuracy Leverrier's Tables will give, and then, by changing one or two hundredths of a second of arc here and there, the second differences were found to run smoothly. For each period of observation the places were then computed for intervals sufficiently short to require interpolation with first differences only.

(2) From the meridian observations at Greenwich (communicated by the Astronomer Royal), the tabular heliocentric longitude of *Mars* was found to require a correction of $-2''{\cdot}45$. The equivalents of this correction in geocentric right ascension and declination were computed and tabulated for each day.

(3) Tables were constructed giving at sight for any hour angle, and for any declination (within the limits of $-9°$ and $-13°$ Decl.), the parallax in right ascension and declination of a celestial object whose distance is *unity*, observed at Ascension—on an assumed value of the mean solar horizontal parallax. A table also was constructed giving the value of $\log \frac{1}{\Delta}$ for *Mars*, so that the computation of the tabular parallax in R.A. and Decl. was reduced to the addition of two logarithms.

(4) The corrections of the stars of comparison, from mean to apparent place, were computed for each fifth day during the period of observation, and rigidly interpolated for every day at Greenwich midnight. The corrections depending on the longitude of the Sun and Moon's perigee, which are omitted in the *Nautical Almanac* day numbers, were not taken into account, as they were also omitted in computing the apparent place of the planet.

From the tables so formed the correction to apparent place was easily taken out at sight for the instant of observation; and this was applied to the mean place of the

star derived from the meridian observations, as given in the preceding paper.*

(5) With the apparent place of the star so found, and with the place of the planet found as in § (1), corrected for tabular error and parallax, §§ (2) and (3), the tabular distance of centres of the star and planet were computed by the formulæ

$$\sin \frac{1}{2} s \sin p_o = \cos \frac{1}{2} (\delta' + \delta) \sin \frac{1}{2} (\alpha' - \alpha),$$

$$\sin \frac{1}{2} s \cos p_o = \sin \frac{1}{2} (\delta' - \delta) \cos \frac{1}{2} (\alpha' - \alpha),$$

where α and δ denote the R.A. and Decl. of the star, α' and δ' the R.A. and Decl. of the planet, s the angular distance of centres, and p_o the mean position angle of the great circle joining star and planet.

(6) The factors in R.A. and Decl., or the effect on the distance of increasing the R.A. and Decl. of the planet by $+1''$, were computed by the formula

$$\text{Factor in R.A.} = f' = \sin p_o \cos \delta,$$

$$\text{Decl.} = f'' = \cos p_o.$$

The parallax factor, or the effect on the distance of increasing the assumed parallax $\frac{1}{100}$ part, was

$$f''' = \frac{f' \times \text{Parallax in R.A.} + f'' \times \text{Parallax in Decl.}}{100}.$$

In this way all the tabular quantities were carefully computed, and in a manner which left hardly any possibility of error.

Take for example :—

* The paper referred to will be printed in the next number of the *Monthly Notices*.

Obs. cccxvii. Sept. 9. Morning. *Mars* and *g*. $\log \frac{I}{\Delta}$ 0·41954.

Rotation No.	Time by Chronometer.	Greenwich Mean Time.	Uncorrected Tabular R.A. of Planet.	Uncorrected Tabular Decl. of Planet.	Star's apparent R.A.	Star's apparent Decl.	Corrections of Tabular Place of the Planet.	
							R.A.	Decl.
		d	° ′ ″			° ′ ″	″	″
1331	3 15 24	9·70624	346 2 6·79	−12 27 49·18	347 14 59·93	−12 13 41·68	−8·46	−3·43
1332	18 57	·70869	4·43	49·68				
1333	20 59	·71010	3·07	49·96				
1334	24 0	·71220	1·05	50·38				

Rotation No.	Parallax in R.A.	Parallax in Decl.	Distance.	p_0		f''	$'''$
			″	° ′			
1331	−20·92	+0·90	4383·89	258 49·2	−0·981	−0·194	+0·204
1332	−21·09	+0·97	86·41	49·3	− ·981	·194	·205
1333	−21·18	+1·01	87·84	49·3	− ·981	·194	·206
1334	−21·31	+1·07	89·98	49·3	− ·981	·194	·207

The independent computation of each tabular quantity enables each bisection to be compared with the tabular result, and any accidental errors to be examined. The factors also enable the individual computations to be used to check each other.

In this way the tabular quantities for 104 observations made between September 4 and September 11 have been computed with great care, and thoroughly checked. The same work is far advanced for the whole of the observations.

5. In computing the instrumental distances—

The results of the division error investigations, made in connection with the *Juno* observations, have been adopted.

The errors of the screw were reinvestigated at Ascension by observations made on 28 days, by a process similar to that employed in connection with the *Juno* observations. In the present case, however, the results rest on a much more perfect series of measures, for spaces equal to $0^{r}\cdot4$, $0^{r}\cdot8$, $1^{r}\cdot2$, and $2^{r}\cdot0$ were measured by all different parts of the screw. The following expressions were found to represent all the series satisfactorily.

For readings on Scale A :

$$0\cdot1518\cos u - 0\cdot0586\sin u - 0\cdot0112\cos 2u + 0\cdot0192\sin 2u - \cdot0120\,n + \cdot0667\,n^2 + \cdot0045\,n^3 - \cdot0050\,n^4 ;$$

For readings on Scale B :

$$0\cdot2075\cos u - 0\cdot0906\sin u + 0\cdot0053\cos 2u + 0\cdot0269\sin 2u - \cdot0238\,n - \cdot0071\,n^2 + \cdot0075\,n^3 + \cdot0106\,n^4 ;$$

where the unit is $\frac{1}{100}$ of a screw revolution, and where n is the number of revolutions reckoned from $2^{r}\cdot0$.

The curves which represent these expressions will be found exactly similar, except that the periodic error and the error depending on the number of revolutions are slightly greater when the reading is made on Scale B than when it is made on Scale A. This error is due to the form of the Repsold micrometer, and the probability of its existence had already been anticipated (see *Dun Echt Observatory Publications*, vol. ii., p. 53) ; the screw errors were purposely determined independently for each scale, in order to find out if a difference of errors would really be found to exist. The greatest divergence of the two curves from mean, however, does not amount to $\frac{1}{50}$ of a second of arc, so that in practice the mean of the two curves has been employed. The run of the screw was found, from a great number of determinations, to be practically constant, and a correction for this was included in the Table of Screw Errors.

The correction for index error was also nearly constant, so that $+1^{r}\cdot15$ added to the readings of Scale B made the arithmetical difference of the scale readings very nearly the true

distance, at least with abundant accuracy for computing the refraction.

The correction to be applied to the measured distance for the effects of refraction was computed by the very accurate formula of Hansen, and the accompanying tables, given by Dr. Seeliger, in his *Theorie des Heliometers*, pp. 96–99:

$$\Delta s = as\,[1 + \tan^2 z_o \cos^2 (p_o - q_o)] + a's \sin^2 (p_o'' - q_o),$$

where

s is the apparent distance,

q_o the parallactic angle of the middle point between the star and planet,

z_o the true zenith distance of the middle point between the star and planet.

For a and a' the logs are given by Dr. Seeliger's tables.

The correction of the mean refraction for the readings of the meteorological instruments was computed as follows:—

For each set of readings of the barometer and thermometer the logarithm of the meteorological factor, according to Bessel, was rigidly computed, and from the figures so obtained a curve was constructed giving the log. factors for each instant of observation.

The true correction for refraction was thus obtained in terms of revolutions of the micrometer screw; and this correction, applied to the instrumental readings, gave the true distance measured in terms of the micrometer screw. These readings were then converted into arc by employing a very approximate value of the screw, deduced from observations of the mutual distances of the comparison stars, whose places were determined by numerous meridian observations. (1 rev. = 25″·7270.)

Finally, a correction for defective illumination was applied equal to + or − half the defect of illumination along that diameter of the planet whose position angle is the same as the position angle of the planet referred to the star of comparison.

This correction was computed as follows:—

If Q = the position angle of greatest defect of illumination,

M = areocentric angle between the Earth and Sun,

p^o = the position angle of the planet relative to the star of comparison,

ρ = planet's true radius, and

$\tan m = \tan \mathrm{M} \cos (p_o - \mathrm{Q})$,

then

$$\left.\begin{array}{l}\text{Correction for distance of centres of star and planet,}\\ \text{when both limbs have been observed}\end{array}\right\} = \rho \sin^2 \frac{1}{2} m.$$

The values of Q and M were taken from Mr. Marth's Ephemeris (*Monthly Notices* for April 1877). In the observations in question this correction is nearly insensible.

6. And now for the all-important question as to how the observations were made, and what precautions taken to eliminate systematic error.

The axis of the heliometer tube having been directed to the middle point between the star and the planet, the position circle set to the computed position angle, and the segments separated to the computed distance, the planet and star appear together in the field of view. Unless the star is very bright, it is found that whenever the observer attempts to place it in the centre of the planet or on the limb of the planet, the star disappears. I had therefore provided myself with three screens, made by Mr. Browning, consisting of one, two, and three folds of wire gauze respectively, any one of which could at pleasure be attached to the head of the instrument. By a small handle at the eye end the screen can be laid over either segment of the object-glass at pleasure; and, in practice, I found the three-fold screen the best for use with *Mars*. With this screen, when the definition was steady, the planet appeared as a clear, sharply defined disk of a dull copper colour, the markings being just visible. It was now easy enough to see the comparison star, when brighter than 8th magnitude, either in the centre of the disk or on the limb of the planet.

An important addition to the heliometer was the small reversing prism, which I exhibited at the meeting of the Society in June 1877.

This prism, attached to a revolving plate on the eye-piece, enabled me not only to measure in all position angles as if the line joining the star and planet was always horizontal, but also to eliminate any tendency I might have to place the star always too much to the right or too much to the left of the planet, by simply reversing the prism 180° between each pair of bisections.

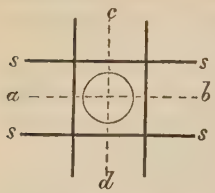
Thus the observations E. and W. of the meridian were made under precisely similar conditions, and were, so far as I can see, entirely free from all systematic error of bisection.

Two methods of observation were followed, which I shall call A and B.

In method A, the star is placed on the estimated centre of the planet, and the scales are read off; then the segments are reversed, the star again is placed in the estimated centre of the planet, and again the scales are read off. Now the small reversing prism is rotated 180°, and the star is placed again in the centre of the planet, and the scales are read off; and finally the segments are reversed to the original position, the star placed in the centre of the planet, and the scales read off. This constitutes one complete observation.

Of course the instant that the star has been placed in the estimated centre is noted by the chronometer, and written down before the scales are read.

When there is considerable phase some care is required in estimating the centre of the disk. The method I adopted was as follows:—



In the field of the eye-piece was a square formed by four flat gold wires; the centre of this square was approximately the true axis of the instrument. The lines *ss*, *ss* marked the direction of separation of the segments. Hence, having placed the planet in the centre of this square, the eye could estimate with great accuracy the imaginary lines *ab* and *cd* respectively parallel and at right angles to *ss*, *ss*, and such that at intersection the portion of each line illuminated by the planet is bisected. The observation may appear complicated in description, but it is easy enough in practice, and the eye appears to be very sensitive in estimating the symmetrical position of the star.

In method B the star is first placed in the centre of the planet, as in method A, and then immediately moved till its disk bisects limb I, time is noted, and the scale read off; the star is again placed in the centre of the planet, and immediately after limb II is bisected, time noted, and the scale read off; then the segments are reversed, and the same operation, in reverse order, is repeated. Thus if $\Delta\theta$ is the error of the assumed index correction, $\Delta\rho$ the error of the assumed radius of the planet, the four readings which make up a complete observation will be

$$\left.\begin{aligned} &s+\Delta\theta-\Delta\rho\\ &s+\Delta\theta+\Delta\rho\\ &s-\Delta\theta+\Delta\rho\\ &s-\Delta\theta-\Delta\rho \end{aligned}\right\} \text{ or } \left\{\begin{aligned} &s-\Delta\theta+\Delta\rho\\ &s-\Delta\theta-\Delta\rho\\ &s+\Delta\theta-\Delta\rho\\ &s+\Delta\theta+\Delta\rho \end{aligned}\right.$$

And this order was always observed.

During the week September (4–11), the observations of which are discussed in the present paper, method B was chiefly employed, in deference to the opinion of the Astronomer Royal; but there are many observations made by method A, and many by method B, not yet reduced.

As an example of the reduction of an observation, I shall take the same case that I have used to illustrate the tabular quantities. (*See* next page.)

I believe the following are the only systematic errors which observations made in the manner I have described can be imagined to be subject to:—

1. Errors of the scale and screw.
2. Errors of the assumed scale or screw value (possibly of a temporary character).
3. Errors of the refraction correction.

Obs. cccxvii. *Mars* and *g*. Sept. 9. Morning.

Rotation No.	Difference of Scale Readings Corrected for Approx. Index Error.	Refraction.	True Instrumental Distance.	In Arc.	Obs. Corrected for $\rho \pm 12''\cdot27$.	Tabular Distance.	O−C.
	r			"	'	"	"
1331	$169\cdot713-\Delta\theta$	·1915	169·9045	4371·13	4383·40	4383·89	$-0\cdot49+\Delta\theta+\Delta\rho$
1332	$170\cdot723-\Delta\theta$	·2034	170·9264	97·42	85·15	86·41	$-1\cdot26+\Delta\theta-\Delta\rho$
1333	$170\cdot762+\Delta\theta$	·2100	170·9720	98·60	86·33	87·84	$-1\cdot51-\Delta\theta-\Delta\rho$
1334	$169\cdot932+\Delta\theta$	·2192	170·1512	77·49	89·76	89·98	$-0\cdot22-\Delta\theta+\Delta\rho$
						Mean	−0·87

Of these sources of error I think I have already sufficiently discussed the first. The errors have been made the object of accurate study* and rigid correction; and even if the errors were much greater than they can possibly be imagined in the instrument in question, their effect on the result must entirely disappear when many different distances, some increasing, some diminishing, are measured.

The second source of error is best disposed of by considering the scale value unknown, and by so selecting the stars of comparison that it may be determined from the observations themselves. This of course implies that the star places are accurately known; but, for reasons which I shall afterwards explain more at length, I have considered this an essential condition in the problem from the beginning, and have provided for it accordingly.

As to the refraction, its effect is simply to diminish the apparent distance between the comparison stars on opposite sides of the planet; therefore, if a term is introduced proportional to the distance, the error of refraction will be almost entirely eliminated. If it is desired to ascertain, for example, how much an error of 1 per cent. in the assumed constant of refraction E. or W. of the meridian would affect the final result, it is easy enough to introduce such terms in the equations, and I propose to do so in the final discussion, though one can see beforehand that the effect must be almost entirely insensible.

The true distance is $= O + \frac{O}{10{,}000} z + \epsilon$ Where O is the observed distance converted into arc 1 rev. = 25″·727, z the correction of this value in 10,000″, and ϵ the error of observation.

The true distance is also $= C + \Delta C$ Where C is the computed tabular distance and ΔC the correction of the tabular distance to actual distance.

Also if

The true R.A. $= \alpha + \Delta\alpha$ Where α is the tabular R.A.,

The true Decl. $= \delta + \Delta\delta$ Where δ is the tabular Decl.,

And the true parallax $= \pi + n \frac{\pi}{100}$,

we shall then have

$$\Delta C = f'\Delta\alpha + f''\Delta\delta + f'''n. \qquad (1)$$

Hence

$$O + \frac{O}{10{,}000} z + \epsilon = C + f'\Delta\alpha + f''\Delta\delta + f'''n,$$

* See *Dun Echt Observatory Publications*, vol. ii. pp. 11–62.

or each observation will give an equation of the type

$$f'\Delta\alpha + f''\Delta\delta + f'''n - \frac{O}{10{,}000}z - \epsilon = O - C. \qquad (2)$$

In the case I selected before we should have for example

$$-\cdot 981\ \Delta\alpha - \cdot 194\ \Delta\delta + 0\cdot 206\ n - \cdot 439\ z - \epsilon = -0\cdot 87.$$

Similarly each observation yields an equation of this form, in which z must be considered different in each set of observations. That is to say, during an hour or two we may consider the scale value constant, or at least changing slowly, the effect of such change being eliminated by the order of arrangement of the observations; but we must not consider it uniform at all times. $\Delta\alpha$ and $\Delta\delta$ can, of course, only be considered uniform so long as we can suppose the tabular errors constant.

A preliminary solution showed that the tabular errors might be fairly represented by expanding them in terms of the time and distance, that is

$$\text{by substituting } \Delta\alpha + \frac{at}{\Delta} \text{ for } \Delta\alpha,$$

$$\text{and by substituting } \Delta\delta + \frac{bt}{\Delta} \text{ for } \Delta\delta,$$

where

t is the time reckoned from Sept. $8^d\cdot 0$;

Δ the distance of the planet from the Earth, the Sun's mean distance being 1;

a and b the daily change of the tabular error in R.A. and Decl. respectively.

Neglecting the term ϵ, which is of course peculiar to each equation, and whose mean value we only desire to find, and making the above-mentioned substitution for $\Delta\alpha$ and $\Delta\delta$, the equations which result from the observations September 4 to 11 are as follows:—

Evening Observations, Sept. 4.

Star of Comp.	Rotation Number.										
											$''$
f	cexxix		·467	$\Delta\alpha$	−·884	$\Delta\delta$	−4·52	a	+8·55	b	+·092	n	−·309	z	=	1·38
k	cexxx	−	·678		+·735		+6·54		−7·09		−·137		−·355		=	−0·92
g	cexxxi		·893		+·450		−8·58		−4·32		+·191		−·092		=	0·73
g	cexxxii		·892		+·452		−8·55		−4·33		+·183		−·091		=	1·93
g	cexxxiii		·891		+·454		−8·53		−4·34		+·177		−·091		=	1·70
g	cexxxiv		·891		+·455		−8·51		−4·35		+·170		−·090		=	0·60
k	cexxxv	−	·687		+·727		+6·54		−6·92		−·123		−·357		=	−1·28
f	cexxxvi		·447		−·895		−4·25		+8·50		+·079		−·308		=	1·06

Evening Observations, Sept. 5.

Star of Comp.	Rotation Number.								
		·161 $\Delta\alpha$	−·987 $\Delta\delta$	−1·13 a	+6 93 b	+·023 n	−·304 z =		1·23
f	ccxxxix								
h	ccxl	−·952	+·258	+6·65	−1·80	−·201	−·226	=	−1·46
g	ccxli	−·659	+·752	+4·58	−5·23	−·115	−·020	=	−1·74
g	ccxlii	−·687	+·723	+4·76	−5·01	−·119	−·020	=	−1·79
g	ccxliii	−·728	+·686	+5·02	−4·73	−·125	−·021	=	−1·61
g	ccxliv	−·746	+·666	+5·13	−4·58	−·125	−·021	=	−1·63
g	ccxlv	−·767	+·642	+5·25	−4 40	−·126	−·022	=	−1·88
g	ccxlvi	−·786	+·619	+5 37	−4·23	−·125	−·022	=	−1·64

Morning Observations, Sept. 5.

g	ccxlvii	−·961 $\Delta\alpha$	+·275 $\Delta\delta$	+6·18 a	−1·77 b	+·037 n	−·036 z =		−1·42
g	ccxlviii	−·964	+·265	+6·18	−1·70	+·047	−·036	=	−1·50
g	ccxlix	−·968	+·250	+6·18	−1·60	+·062	−·038	=	−1·25
g	ccl	−·971	+·240	+6·18	−1·53	+·074	−·038	=	−2·07
g	ccli	−·973	+·231	+6·17	−1·46	+·083	−·039	=	−2·06
g	cclii	−·975	+·222	+6·16	−1·40	+·094	−·040	=	−1·71
g	ccliv	−·986	+·171	+6·10	−1·06	+·158	−·045	=	−1 87
g	cclv	−·986	+·165	+6·08	−1·02	+·165	−·045	=	−1·15
g	cclvi	−·988	+·155	+6 07	−0·95	+·177	−·046	=	−1·62
g	cclvii	−·989	+·140	+6·02	−0·85	+·196	−·048	=	−0 93
g	cclviii	−·991	+·130	+6·01	−0·79	+·204	−·049	=	−1·46
g	cclix	−·992	+·126	+5·99	−0·76	+·211	−·050	=	−1·32

Evening Observations, Sept. 6.

f	cclx	−·142 $\Delta\alpha$	−·990 $\Delta\delta$	+0·62 a	+4·34 b	−·046 n	−·329 z =		0·73
g	cclxi	−·996	−·094	+4·25	+0·40	−·197	−·110	=	−1·90
g	cclxii	−·995	−·095	+4·24	+0·40	−·191	−·111	=	−0·52
e	cclxiii	·992	+·125	−4·20	−0·53	+·181	−·593	=	1·22
e	cclxiv	·992	+·125	−4·18	−0·53	+·174	−·593	=	0·52
	cclxv	−·991	+·134	+4·15	−0·56	−·166	−·319	=	−0 90
g	cclxvi	−·995	−·100	+4·15	+0·42	−·159	−·114	=	−0 96
g	cclxvii	−·995	−·101	+4·14	+0·42	−·152	−·115	=	−0·88
f	cclxviii	−·168	−·986	+0·69	+4·07	−·017	−·332	=	0·45
f	cclxix	−·170	−·985	+0·70	+4·06	−·014	−·333	=	0·19

Morning Observations, Sept. 6.

	cclxx	−·993 $\Delta\alpha$	−·119 $\Delta\delta$	+3·65 a	+0·44 b	+·096 n	−·135 z =		−1·63
	cclxxi	·993	−·121	−3·57	−0·44	·134	−·567	=	1·32

Star of Comp.	Rotation Number.							
								"
e	cclxxii	·993	+·120	−3·55	−0·43	−·146	−·566	= 1·50
h	cclxxiii	−·994	+·105	+3·50	−0·37	+·169	−·345	= −1·29
g	cclxxiv	−·992	−·124	+3·43	+0·43	+·190	−·144	= −1·69

Evening Observations, Sept. 7.

h	cclxxvi	−·999	Δα +·050	Δδ +1·72	*a* −0·09	*b* −·219	*n* −·406	*z* =	−0·46
e	cclxxvii	·995	+·103	−1·67	−0·17	+·209	−·499	=	0·64
e	cclxxviii	·995	+·101	−1·55	−0·16	+·171	−·495	=	0·93
g	cclxxix	−·986	−·166	+1·52	+0·26	−·162	−·212	=	−1·31
g	cclxxx	−·986	−·167	+1·51	+0·26	−·154	−·212	=	−0·89
f	cclxxxi	−·395	−·919	+0·59	+1·38	−·053	−·383	=	−0·65
k	cclxxxii	−·946	+·324	+1·40	−0·48	−·134	−·565	=	−1·02
γ	cclxxxiii	·810	+·586	−1·18	−0·86	+·099	−·649	=	−0·06

Morning Observations, Sept. 7.

e	cclxxxvi	·995	Δα +·096	Δδ −1·02	*a* −0·10	*b* −·103	*n* −·473	*z* =	0·54
g	cclxxxvii	−·985	−·171	+0·99	+0·17	+·115	−·234	=	−1·14

Evening Observations, Sept. 8.

h	ccxc	−1·000	Δα −·005	Δδ −·092	*a* −0·00	*b* −·216	*n* −·501	*z* =	−0·89
e	ccxci	·998	+·070	+1·01	+0·07	+·191	−·400	=	−0·20
g	ccxcii	−·982	−·187	−1·01	−0·19	−·182	−·307	=	−0·45
g	ccxciii	−·982	−·187	−1·03	−0·20	−·177	−·308	=	−0·33
e	ccxciv	·998	+·069	+1·07	+0·07	+·170	−·398	=	−0·15
h	ccxcv	−1·000	−·008	−1·09	−0·00	−·162	−·507	=	−0·19
e	ccxcvi	·998	+·068	+1·12	+0·08	+·152	−·396	=	+0·42

Morning Observations, Sept. 8.*

d	ccxcvii	·736	Δα −·677	Δδ +1·13	*a* −1·04	*b* −·041	*n* −·694	*z* =	1·40
k	ccxcviii	−·972	+·235	−1·54	+0·37	+·086	−·666	=	−1·76
γ	ccxcix	·759	+·651	+1·21	+1·04	−·088	−·544	=	0·03
f	ccc	−·577	−·817	−0·94	−1·33	+·078	−·463	=	−0·55
e	ccci	·998	+·060	+1·66	+0·10	−·132	−·374	=	0·47
g	cccii	−·982	−·188	−·165	−0·32	+·141	−·332	=	−0·54
h	ccciii	−·999	−·017	−1·70	−0·03	+·151	−·532	=	0·00
e	cccv	·998	+·058	+1·84	+0·11	−·201	−·366	z' =	1·18
h	cccvi	−1·000	−·019	−1·87	−0·04	+·209	−·539	z' =	−0·38

* There was a long interval between the observations ccciii and cccv, an interruption by clouds; it was thought best to suppose that the scale value might have changed in the interval, hence the term z' as distinguished from z.

Evening Observations, Sept. 9.

| Star of Comp. | Rotation Number. | | |

Star of Comp.	Rotation Number.							
								"
g	ccccxxxix	−·981	−·196	−8·59	−1·72	−·206	−·591	= −0·28
μ	ccccxl	·965	+·263	+8·47	+2·31	+·196	−·389	= 0·39
μ	ccccxli	·965	+·263	+8·49	+2·31	+·189	−·389	= −0·03
g	ccccxlii	−·981	−·196	−8·66	−1·73	−·183	−·594	= −0·47
e	ccccxliii	·965	−·262	+8·55	−2·32	+·168	−·121	= 0·38

Since the errors of the star places are small as compared with the probable error of observation, and since nearly the same stars are observed in the evening and morning, we may assume that the star places are absolutely known.

There might be certain advantages in taking only pairs of observations in which the same stars are observed evening and morning, but this course necessarily involves the sacrifice of many observations. The observer, of course, always endeavours to employ the same stars in the evening and morning, but bad weather may come and he is only able to secure a portion of the observations. If he misses observations of certain stars on one evening, he endeavours to secure them on the next, and so on. Thus whilst upon the whole he can preserve a fair balance of evening and morning observations in which the same stars are employed, it is quite impossible to get a series of pairs of evening and morning observations of nearly equal weight, in which exactly the same stars have been used.

There is also always something arbitrary in obtaining the final result from such pairs of observations, a feeling that many good observations have been rejected for no sufficient reason, and the sacrifice of the advantage which the simultaneous treatment of all the observations offers, in determining the errors of the Tables and detecting outstanding observations.

The kind and energetic co-operation of so many observatories enables me to assign, even now, places of the stars whose probable error does not exceed $\frac{1}{10}$ of a second of arc, and when I have received the additional series which I expect, and these have been incorporated with the heliometric triangulation, I believe the probable error of each star's place will prove to be not greater than $\pm$ 0″·05.

These are the reasons which guided me to the decision that the final discussion must he made in the way I have described; and that decision once arrived at, all the equations admit of only one solution.

The following are the successive steps:—

I. From each group of equations normal equations must be formed, by the ordinary method of least squares, for each of the unknown quantities

$$\Delta\alpha,\ \Delta\delta,\ a,\ b,\ n,\ z.$$

II. Since z (which expresses the error of the assumed scale value) cannot be considered the same in each group, it is necessary to eliminate it before combining the various groups.

When three or more stars surrounding the planet have been observed, the elimination of z can of course be rigidly accomplished.

When only two stars have been observed (unless the planet is exactly in the line joining the stars), of course the data are wanting for projecting the planet on the line joining the stars. In such a case, however, everything represented by the observations will be obtained by multiplying the coefficient of z in the normal equation in z by such a number as will make it equal to the coefficient of z in the normal for $\Delta\alpha$, and then subtracting the equation so found from the normal in $\Delta\alpha$—eliminating, in fact, z from the normal in $\Delta\alpha$. Similarly z is to be eliminated from the other normals. In fact, in all cases, whatever the number of stars observed, this is the only admissible method of eliminating z, as it does not affect the determination of weight.

When only one star has been observed, the elimination of z is of course impossible without further data. On the morning of September 5 *Mars* was so near to the star g, and so favourably situated as to position angle (280°), that in order to secure a weighty result, this star alone was observed, but in the middle of the observations the distance between the stars e and g was measured and found to be

$$\overset{\mathrm{r}}{274{\cdot}2184}.$$

or, converted into arc by our adopted screw value,

$$\overset{''}{7054{\cdot}89} + 0{\cdot}705\, z.$$

The tabular apparent distance of the stars e–g was

$$\overset{''}{7054{\cdot}84},$$

whence

$$7054{\cdot}89 + 0{\cdot}705\, z = 7054{\cdot}84,$$

or

$$z = -0{\cdot}28.$$

And this value of z was substituted in the normal equation for $\Delta\alpha$, $\Delta\delta$, a, b, and n, for September 5, morning observations.

III. The various values of z having been eliminated by the above methods from the normal equations, all the normals in $\Delta\alpha$ were added together, and similarly all the normals in $\Delta\delta$, a, b, and n, and so the final five normal equations were obtained:—

$$\begin{aligned}
81{\cdot}4\ \Delta\alpha - 1{\cdot}88\ \Delta\delta - 3{\cdot}09\, a + 39{\cdot}6\, b + 1{\cdot}43\, n &= 81{\cdot}42,\\
-1{\cdot}89 + 17{\cdot}5 + 40{\cdot}2 - 45{\cdot}3 + 0{\cdot}01 &= -9{\cdot}20,\\
-4{\cdot}00 + 40{\cdot}2 + 2440{\cdot}0 - 220{\cdot}0 + 6{\cdot}01 &= -176{\cdot}3,\\
40{\cdot}3 - 45{\cdot}3 - 220{\cdot} + 721{\cdot} + 2{\cdot}93 &= 80{\cdot}76,\\
1{\cdot}44 + 0{\cdot}12 + 6{\cdot}03 + 2{\cdot}93 + 2{\cdot}38 &= 0{\cdot}686.
\end{aligned}$$

The solution of these gives the following values :—

	′	Weight.
$\Delta\alpha =$	0·993	78·7
$\Delta\delta = -$	·203	14·3
$a = -$	·0628	2500·
$b =$	·0277	589·
$n = -$	·761	2·33.

When these values are substituted in the original equations together with value of z which results from the substitution of these values in the normal for z, the following are the residuals :—

Star of Comp.	Rotation Number.	″
	Evening, Sept. 4.	
f	ccxxix	−0·08
k	ccxxx	− ·17
g	ccxxxi	+ ·40
g	ccxxxii	− ·80
g	ccxxxiii	− ·57
g	ccxxxiv	+ ·54
k	ccxxxv	+ ·17
f	ccxxxvi	+ ·21
	Evening, Sept. 5.	
f	ccxxxix	−0·43
h	ccxl	+ ·29
g	ccxli	+ ·60
g	ccxlii	+ ·63
g	ccxliii	+ ·41
g	ccxliv	+ ·41
g	ccxlv	+ ·65
g	ccxlvi	+ ·31
	Morning, Sept. 5.	
g	ccxlvii	−0·05
g	ccxlviii	+ ·02
g	ccxlix	− ·24
g	ccl	+ ·57
g	ccli	+ ·56
g	cclii	+ ·20
g	ccliv	+ ·32
g	cclv	− ·40
g	cclvi	+ ·07
g	cclvii	− ·63
g	cclviii	− ·10
g	cclix	− ·25
	Evening, Sept. 6.	
f	cclx	−0·82
g	cclxi	+ ·52
g	cclxii	− ·86
e	cclxiii	+ ·24
e	cclxiv	+ ·94
h	cclxv	− ·01
g	cclxvi	− ·39
g	cclxvii	− ·46
f	cclxviii	− ·54
f	cclxix	− ·27
	Morning, Sept. 6.	
g	cclxx	+0·41
e	cclxxi	+ ·09
3	cclxxii	− ·08
h	cclxxiii	+ ·01
g	cclxxiv	+ ·42
	Evening, Sept. 7.	
h	cclxxvi	−0·65
e	cclxxvii	+ ·06
e	cclxxviii	− ·20
g	cclxxix	+ ·31
g	cclxxx	− ·11
f	cclxxxi	+ ·33
k	cclxxxii	− ·22
γ	cclxxxiii	− ·45

Star of Comp.	Rotation Number.	"
	Morning, Sept. 7.	
e	cclxxxvi	+0·09
g	cclxxxvii	− ·18
	Evening, Sept. 8.	
h	ccxc	−0·07
e	ccxci	+ ·82
g	ccxcii	− ·40
g	ccxciii	− ·53
e	ccxciv	+ ·78
h	ccxcv	− ·80
e	ccxcvi	+ ·22
	Morning, Sept. 8.	
d	ccxcvii	−0·60
k	ccxcviii	+ ·79
γ	ccxcix	+ ·61
f	ccc	+ ·10
e	ccci	+ ·51
g	cccii	− ·38
h	ccciii	−1·00
e	cccv	+0·19
h	cccvi	− ·13
	Evening, Sept. 9.	
e	cccvii	−0·43
g	cccviii	+ ·31
	Morning, Sept. 9.	
d	cccix	−1·01
θ	cccx	+0·61
g	cccxi	− ·14
e	cccxii	− ·07
e	cccxiii	− ·04
g	cccxiv	+ ·14
g	cccxv	+ ·34
e	cccxvi	− ·01
g	cccxvii	+ ·33
e	cccxviii	− ·03
	Evening, Sept. 10.	
e	cccxix	−0·13
g	cccxx	+ ·14
g	cccxxi	− ·63
e	cccxxii	+ ·14
θ	cccxxiii	+ ·42
d	cccxxv	− ·47
f	cccxxvi	− ·16
γ	cccxxvii	+1·04
	Morning, Sept. 10.	
e	cccxxix	−0·34
g	cccxxx	+ ·57
g	cccxxxi	− ·01
e	cccxxxii	− ·23
e	cccxxxiii	− ·64
g	cccxxxiv	+ ·04
g	cccxxxv	− ·16
e	cccxxxvi	− ·08
	Evening, Sept. 11.	
e	cccxxxvii	+0·06
g	cccxxxviii	+ ·05
g	cccxxxix	− ·12
μ	cccxl	− ·18
μ	cccxli	+ ·25
g	cccxlii	+ ·05
e	cccxliii	− ·12

From these residuals the probable error of one observation, including the error of the heliometer measure and the error of the star's place, is

$$\pm 0''{\cdot}302.$$

With this probable error we now find the probable error of the various results

$$= \frac{\text{probable error}}{\sqrt{\text{weight}}},$$

and we have

$$\begin{aligned}
\Delta\alpha &= \quad 0''\cdot993 \quad \pm 0''\cdot034, \\
\Delta\delta &= - \ \cdot203 \quad \pm 0''\cdot080, \\
a &= - \ \cdot0628 \quad \pm 0''\cdot0060, \\
b &= \quad \cdot0277 \quad \pm 0''\cdot0124, \\
n &= - \ \cdot761 \ \% \pm 0''\cdot198 \ \%,
\end{aligned}$$

$$\left.\begin{array}{l}\text{or correction of assumed} \\ \odot \text{ parallax}\end{array}\right\} = - \ 0''\cdot067 \quad \pm \ 0''\cdot0174.$$

I would have preferred not to have communicated this result in its present form, but to have waited until it was possible to deduce the definitive result from all the observations.

I think I have sufficiently shown how very desirable it is to start in the final discussion with star places of the highest possible accuracy. That condition I can only secure by a complete and thorough discussion of all available material, including those interesting questions as to personality in R.A. observations to which I have referred in my previous paper. I can hardly receive the results of these special observations before the end of the year, and there remains besides the discussion of the triangulation, which is a long and tedious operation.

I am continually being pressed by the Fellows for results, and it is by the advice of the Astronomer Royal that I have given the report in its present form. It will, at least, enable the Fellows to see that no time has been lost; and I trust it may also be the means of prompting valuable criticism.

It appears that the probable error of one observation is not greater than, if so great as, that of an average transit of *Venus* contact observation, whilst the parallax factors are about the same. Thus a single observer, on a single clear night, can do as much for the determination of the solar parallax as nine or ten costly transit expeditions; the observations also possess one enormous advantage, that they are only capable of one interpretation.

I have rejected no complete observation between September 4 and 11, but during that period only a little more than one-fourth of the total number of observations were made. It would appear then that the final result will be one of very great accuracy if it is not affected by any systematic error.

I have not found it possible to conceive any form of systematic error to which the observations are liable; but on this point I most earnestly invite criticism and suggestion, either now or at a future time.

There is only one form of criticism which is useless, and it is one which is unfortunately too common, viz. that the result is right or wrong according as it agrees with the critic's preconceived notions as to what it should be. It is for this reason I have not published the value of the assumed parallax; and as all useful criticism can equally well be made without this information, I think it is better to defer the publication of any value of the parallax until the definitive result is arrived at.

On Newcomb's Correction to Hansen's Value of the Secular Acceleration. By E. Neison, Esq.

Prof. Newcomb, in his recent valuable researches on the motion of the Moon (*Washington Observations*, 1875, Appendix ii., 1878), by comparing Hansen's *Tables de la lune* with the observations of the eclipses recorded by the Alexandrian and Arabian astronomers, has shown that Hansen has assigned too great a value to the mean motion and secular acceleration of the Moon. Further, by comparing Hansen's tables with the early observations of the Moon made between 1600 and 1750, Prof. Newcomb shows that the tables entirely fail to represent these observations.

By diminishing the secular acceleration by $3''\cdot86$ and the secular mean motion by $29''\cdot17$, and by rejecting one of Hansen's terms of long period in accordance with Delaunay's researches, and by empirically diminishing by 60° the constant part of the argument of the other, it is possible, as Prof. Newcomb shows, to make Hansen's tables closely represent the motion of the Moon for the whole period, 1625–1875, and very much improve the manner with which they represent the eclipses recorded by the Arabian and Alexandrian astronomers. In this manner Prof. Newcomb obtains $8''\cdot31$ for the value of the secular acceleration of the mean motion which is indicated by observations, a much closer approximation to the theoretical value, $6''\cdot18$, than had hitherto been obtained.

Apart from other considerations this result is of very considerable importance, because it throws much doubt on the supposed tidal retardation of the rotation of the Earth, an hypothesis which has given rise to much speculation, though it has not yet been proved to be possible for the terrestrial tides to produce a secular retardation of the rotation of the Earth.

I wish to show that there is one point in Prof. Newcomb's researches which he seems to have overlooked, and that is, that the value which he assigns to the diminution in Hansen's secular acceleration depends almost entirely on the weight to be assigned to a single eclipse in the numerous series employed by him; so that, by rejecting this eclipse, or by assigning to it a different weight, very great modifications will be introduced

into the amount by which Hansen's secular acceleration is to be corrected.

The principal data employed by Prof. Newcomb are thirteen eclipses of the Moon of which observations are recorded by Ptolemy, and twenty-two eclipses of the Sun and Moon observed by the Arabian astronomers between 820 and 1004. From these observations, united into groups, Prof. Newcomb derives the following corrections to Hansen's tables:—

Obs.	Epoch.			Weight.	Obs.	Epoch.			Weight.
(3)	−687.	$\delta\zeta$ = −11′	±4′	3,					
(3)	−381.	„ = −27′	±5′	2,	(3)	850.	$\delta\zeta$ = −3′·8	±2′·4	8,
(8)	−189.	„ = −20′	±3′	4,	(7)	927.	„ = −1′·6	±1′·7	16,
(3)	+137.	„ = −16′	±4′	3.	(20)	986.	„ = −4′·5	±1′·3	30.

After correcting Hansen's value of the secular acceleration and mean motion, the tables represent these observations with the following residuals.

Epoch.	′	Epoch.	′
−687	= +17,		
−381	= − 7,	850	= −2′·8,
−189	= − 4,	927	= −0′·9,
+137	= − 6.	986	= −4′·2.

It is obvious that the tables, even when amended, do not satisfactorily represent the observations of these eclipses, since (with a single exception) all the errors tend in one direction. It is in fact impossible to represent the first group of eclipses (mean epoch = −687), without introducing enormous discordances in the others; but if this group be rejected, all the others can be well represented. This discordant group of eclipses consists of four, as follows:—

−720	March	19	$\delta\zeta$ = − 4′	± 6′,
−711	March	8	„ = −36′	±22′,
−711	September	1	„ = −22′	±11′,
−620	April	21	„ = −23′	±11′.

Prof. Newcomb rejects the second of these, because it is not specially stated whether the beginning or middle of the eclipse was observed, and combines the other three by assigning to them the weights 3, 1, 2 respectively. The first eclipse has therefore a very preponderating weight attached to it. It is evident, however, that this eclipse is entirely discordant, for it indicates a very small positive correction, whereas all the others retained by Newcomb show very much larger corrections. The mean of the two other eclipses is −23′, and the mean of all four −21′. By giving this high weight to this one eclipse Prof. Newcomb has rendered its importance so great that it almost overbalances all the others, not only in this group but in all the others.

If this single discordant eclipse be rejected, but in all other respects the data employed by Prof. Newcomb be retained, whilst the other corrections remain sensibly unaltered, the value of the correction to the secular acceleration rises from $-3''{\cdot}81$ to $-4''{\cdot}80$. As Prof. Newcomb regards the two other eclipses as doubtful, it seems more satisfactory to reject the entire group, and solve the equations without them. In this way, whilst the correction to the epoch and mean motion remain almost entirely unchanged, the correction to the secular acceleration becomes $-4''{\cdot}97$ instead of $-3''{\cdot}81$. In this way the ancient eclipses are far better represented, the residuals being

$$-381 = +2'{\cdot}4 \qquad 850 = -0'{\cdot}8,$$
$$-189 = +3'{\cdot}9 \qquad 927 = +0'{\cdot}6,$$
$$+134 = -0'{\cdot}2 \qquad 986 = -2'{\cdot}8.$$

The rejected group is

Obs.	Epoch.		Weight.	
(2)	$-660.\delta\zeta = -23 \pm 9$	1,		residual $= +15'$

The observations between 1625 and 1875 are still better represented by this value than by that employed by Prof. Newcomb. The result shows that Hansen's value of the secular acceleration can be reduced to as low as $7''{\cdot}20$ or only a single second greater than the theoretical value, $6''{\cdot}18$.

When the Arabian observations of eclipses and the modern observations between 1625 and 1875 are considered alone, they are best represented by the theoretical value of the secular acceleration. Thus, by diminishing Hansen's mean motion by $30''$ per century, and his secular acceleration by $6''$, so as to obtain the theoretical value, the tables as amended represent not only the observations between 1625 and 1875, but also the Arabian observations, the residuals being

$$\left.\begin{aligned} 850 &= +0'{\cdot}6 \\ 927 &= +1'{\cdot}6 \\ 986 &= -1'{\cdot}9 \end{aligned}\right\} = -0'{\cdot}7.$$

Even the ancient observations are represented as well as by Prof. Newcomb's correction, the residuals being

$$-660 = +17',$$
$$-381 = +\ 7',$$
$$-189 = +\ 7',$$
$$-134 = +\ 3'.$$

These results render very problematical the existence of any tidal retardation in the rotation of the Earth, by showing that it is possible to tolerably well represent the motion of the Moon with only the theoretical value of the secular acceleration.

It is remarkable that the ancient eclipses should uniformly indicate a greater value for the secular acceleration than the Arabian observations. In fact, to reconcile the two it is essential to suppose that there exists a term of very long period in the Moon's longitude. A term with a period of two or three thousand years—and it has been already shown that terms of this period exist—and a coefficient only three or four times larger than that of Hansen's term would completely reconcile the two classes of observations.

Observations of the Periodic Comet of Tempel, 1878.

By Prof. C. Pritchard.

Oxford Mean Time of Observation.	Apparent R.A. of Comet.	Log Factor of Parallax in R.A.	Apparent N.P.D. of Comet.	Log Factor of Parallax in N.P.D.	Star of Comparison.
h m s	h m s		° ′ ″		
July 27 10 40 25·8	15 26 2·29	8·5287	97 29 57·7	9·9150	*a*
„ 28 11 10 2·5	15 27 26·01	8·5564	97 55 46·9	9·9125	*b*
„ 31 10 8 42·3	15 31 52·86	8·4972	99 14 28·5	9·9228	*c*
„ 31 10 11 47·7	15 31 52·93	8·5023	99 14 26·7	9·9224	*c*
Aug. 1 10 10 31·5	* 4 18·63	8·5069	* 5 6·3	7·9230	

The assumed mean positions of the stars for January 1, 1878, are

	h m s	° ′ ″
a	15 26 33·85	97 40 8·7
b	15 28 11·06	97 31 20·9
c	15 32 55·37	99 11 17·8

The Comet resembled a faint round nebula of about 1′ in diameter. The condensation was very slight, and the observations refer to the centre of the nebulosity. The observation on July 28 is very uncertain, unfavourable atmospheric circumstances rendering the comet very faint. The second observation on July 31 was made by Mr. Jenkins. The star of comparison on August 1 has not been found in any Catalogue. The observations were made with the Grubb 12¼-inch refractor, by the first assistant, Mr. W. Plummer.

Observation of Encke's Comet. By J. Tebbutt, Esq.

With the help of Dr. von Asten's Ephemeris, in No. 2197 of the *Astronomische Nachrichten*, I succeeded in finding Encke's Comet on the evening of the 3rd instant. It presented the appearance of a small round nebula gradually condensed towards the centre, and was within a few minutes of arc of the position

assigned to it in the Ephemeris. I had not time to get a comparison observation. The following night was very cloudy, and the comet could not therefore be observed. On the evening of the 5th, however, I obtained four comparisons with Lalande 20142, which give the following position for the comet :—

Aug. 5^d 6^h 29^m 44^s Windsor M.T. { App. R.A. = 10^h 16^m $14^s.2$; App. N.P.D. = 83° 42′ 31″

It has been observed on every evening since the 5th, but on the 11th, 12th, and 13th it was excessively faint owing to the increased moonlight. I will forward the observations to the Society when they are completed and reduced. I avail myself of this opportunity to state that I have on several occasions searched for Tempel's comet II. 1873, in the rough positions given in *Nature* of the 21st of March last, but in vain.

Observatory, Windsor, N. S. Wales,
August 14, 1878.

Double Star Observations made in 1877–8 *at Chicago with the* 18½*-inch Refractor of the Dearborn Observatory, comprising, I. A Catalogue of* 251 *Double Stars; II. Micrometrical Measures of* 500 *Double Stars.* By S. W. Burnham, Esq.

(*Abstract.*)*

The astronomical observations contained in the paper were made between July 22, 1877, and October 15, 1878. The new double stars are numbered consecutively with those in the author's former Catalogues published as follows :—

First Catalogue	Nos. 1 to 81	*Monthly Notices R.A.S.*,	March 1873.
Second ,,	82 ,, 106	,, ,,	May 1873.
Third ,,	107 ,, 182	,, ,,	Dec. 1873.
Fourth ,,	183 ,, 229	,, ,,	June 1874.
Fifth ,,	230 ,, 300	,, ,,	Nov. 1874.
Sixth ,,	301 ,, 390	*Astron. Nach.*, No. 2062.	
Seventh ,,	391 ,, 436	,, 2103.	
Eighth ,,	437 ,, 452	*American Jour. of Science*,	July 1877.
Ninth ,,	453 ,, 482	*Monthly Notices R.A.S.*,	Dec. 1877.

The present work forms the tenth Catalogue of the series and extends the number of new pairs to 733. Of the 251 pairs in this list, 75 pairs are from 0″ to 1″ in distance, and 59 pairs from 1″ to 2″.

* The Paper will be published *in extenso* in the volume of *Memoirs*.—Ed.